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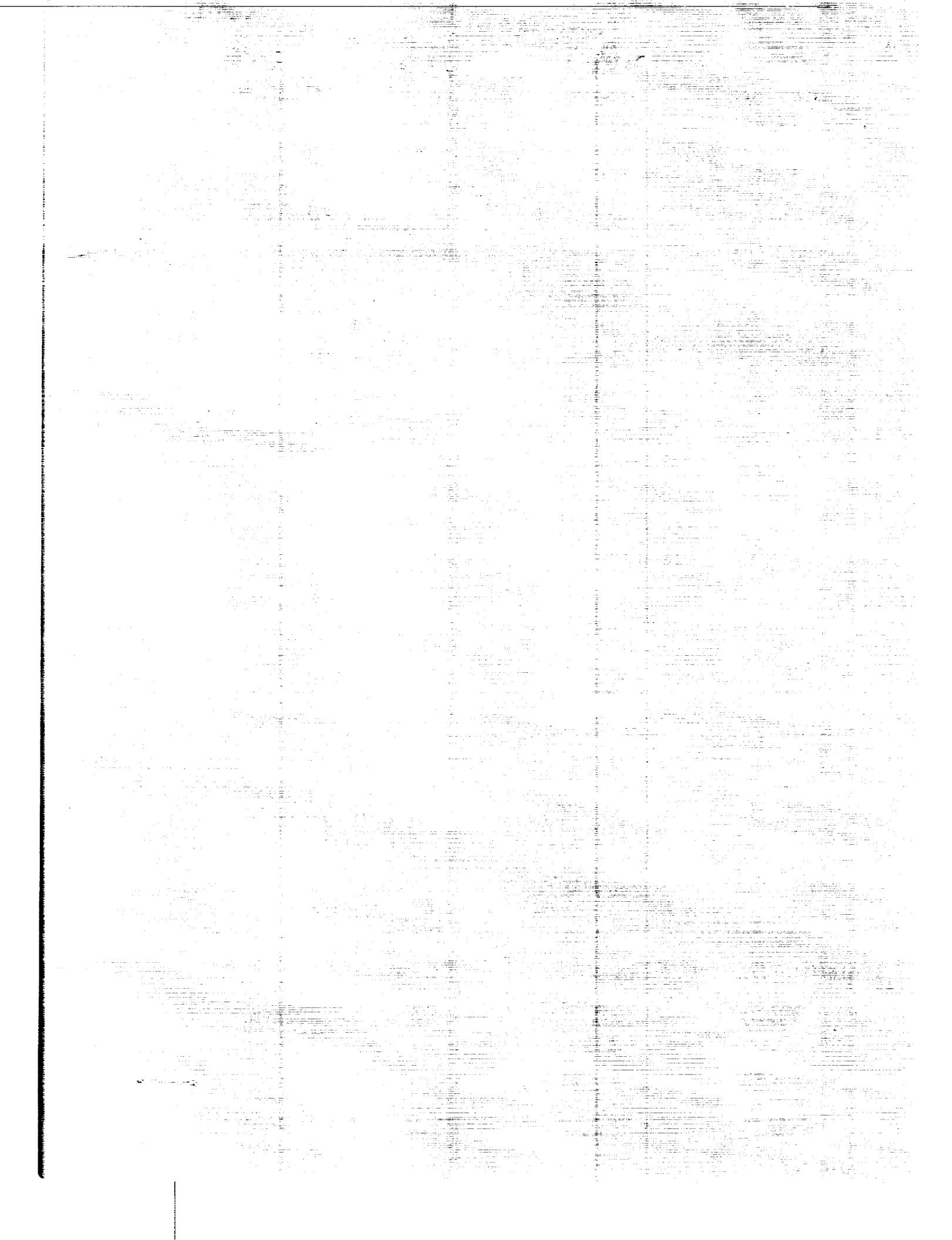
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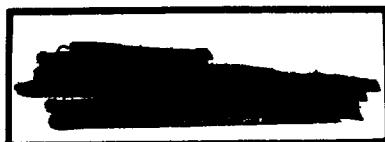
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FOREBODY TEMPERATURES AND CALORIMETER HEATING RATES
MEASURED DURING PROJECT FIRE II REENTRY
AT 11.35 KILOMETERS PER SECOND

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SUMMARY

The Project Fire II reentry has provided calorimeter heating measurements on a large-scale blunt body entering the earth's atmosphere at an initial velocity of 11.35 kilometers/second. The heating rates are consistent with those for the previously reported Project Fire I reentry when the latter are adjusted for differences in reentry velocity and ambient density. A maximum heating rate of 1140 watts/centimeter² was indicated at an altitude of 49 kilometers and a velocity of 9.92 kilometers/second. Radiative heating was indicated to be an important contributor during the middle 12 seconds of the 40-second heat pulse.

INTRODUCTION

The reentry heating environment associated with vehicles returning to the earth from the moon or near planets has been the subject of considerable study in recent years. Much effort has been expended in developing theoretical methods for predicting the heating rates. However, because of the complexity of the physical phenomena involved, some uncertainties still exist at these high reentry velocities where the radiative heating mode becomes important. In an effort to narrow these uncertainties, the National Aeronautics and Space Administration undertook Project Fire to provide flight data on a relatively large-scale blunt body reentering the earth's atmosphere at a nominal velocity of 11.28 kilometers/second.

The first of two Project Fire space vehicles was launched on April 14, 1964, from Cape Kennedy, Florida. A successful reentry at a velocity of 11.57 kilometers/second and reentry angle of -14.6° was accomplished approximately 8334 km down the Eastern Test Range near Ascension Island. The reentry trajectory and the experimental results derived from the onboard experiments have been reported in references 1 to 5. The second and final Project Fire space vehicle was launched on May 22, 1965, and a

successful reentry was again achieved. The initial reentry velocity was 11.35 kilometers/second (37 239 ft/sec) at a flight-path angle of -14.7°.

The initial published Fire II results, as well as a discussion of the principal Fire I and Fire II experiments, are contained in reference 6. The primary purpose of the present report is to make available the detailed forebody temperature-time history measurements obtained from the Fire II reentry.

SYMBOLS

The International System of Units has been used throughout this report. In certain instances where it may be of interest to the reader the U.S. Customary Units have been added.

A,d	polynomial coefficients
c	specific heat capacity of beryllium, joules/kg-°K
D	diameter of forebody calorimeter layer, cm
i	integer
k	thermal conductivity of beryllium, joules/cm-sec-°K
L	total thickness of beryllium calorimeter plug (0.508 cm)
q	stagnation accumulative heat load, $\int_{t=1620}^{t=t} (\dot{q}_c + \alpha \dot{q}_r) dt$, joules/cm²
\dot{q}	local heating rate, watts/cm²
R	radius of forebody calorimeter layer measured perpendicular to axis of symmetry, cm (see fig. 12)
R_C	corner radius of calorimeter layer, cm
R_N	forebody nose radius, cm
s	radial distance measured perpendicularly from axis of symmetry, cm (see fig. 12)

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T temperature, °K
t time, sec
x distance into calorimeter measured normal to heated surface, cm
 α total hemispherical absorptance of beryllium, dimensionless
 ϵ total hemispherical emittance of beryllium, dimensionless
 ρ density of beryllium, 1.85×10^{-3} kg/cm³
 σ Stefan-Boltzmann constant, 5.6697×10^{-12} watts/cm²-(°K)⁴
 ϕ azimuth angle, deg

Subscripts:

c convective
em emitted from front
i summation index
j,k range indices
0 heated surface
ob emitted out back
r radiative
s stored

DESCRIPTION OF REENTRY EXPERIMENT

Detailed descriptions of the Project Fire II reentry experiment are given in references 6 and 7. The experiment was designed so that the forebody temperature data were collected during reentry in three experimental periods as shown in figure 1. The Fire II

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reentry conditions and measurements, other than the velocity differences previously noted, were similar to those of Fire I with the exceptions that the reentry trajectory was moved uprange approximately 160 km, somewhat closer to Ascension Island, and that the nominal timing of the third experimental period was advanced by 2 seconds.

A sketch of the space vehicle used for Project Fire is shown in figure 2. The various phases of the trajectory and sequence of major events prior to reentry are depicted in figure 3 and the Fire II trajectory is defined in figure 4. A velocity of 11.35 km/sec at an altitude of 121.92 km (400 000 ft) and a reentry angle of -14.7° was achieved. The local atmospheric pressure, density, and temperature obtained from a sounding made shortly after reentry are presented in figure 5.

Reentry Package

Physical description.- The general shape and external dimensions of the reentry package are shown in figure 6. The reentry package consisted of a blunt spherical forebody joined to a conical afterbody. The reentry package was symmetric about its longitudinal axis and was designed to enter the atmosphere with its blunt face foremost, the longitudinal axis being at an angle of attack of 0°.

In order that the forebody heating measurements be made in a contamination-free atmosphere, it was necessary to utilize relatively clean metallic (beryllium) calorimeter layers during the time when meaningful measurements were to be made. Since no single calorimeter layer could survive the heat load of the entire reentry without considerable surface melting and mass loss, a means was devised to utilize a metallic layer until it began to melt and then to mechanically expose a new cool layer that would provide additional clean experiment time.

As shown in figure 7, the forebody of the reentry package was constructed with three beryllium calorimeter shields which were alternated with phenolic-asbestos heat shields. The phenolic-asbestos layers were used to protect the succeeding beryllium layers until the desired exposure times just prior to and after peak heating. This multiple layer arrangement provided three distinct experimental or data-gathering periods during the reentry as shown in figure 1.

After the ejection of a given heat-shield layer, slightly different forebody dimensions existed. The dimensions pertinent to each experiment period are indicated in the table shown in figure 6. At the beginning of reentry, the maximum diameter of the reentry package was 67.16 cm and its total mass was approximately 86.57 kg.

The first and third beryllium layers were 0.3048 cm (0.12 in.) thick, except in the vicinity of the temperature sensors where the thickness was increased to 0.5080 cm (0.20 in.) by bosses on the rear surface. The second layer, which was designed to be

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exposed during the peak heating period, was a constant 0.5080 cm thick. Each layer was machined from the same hot-pressed beryllium block. The exposed surface of each layer was polished to a surface finish of approximately $0.2\text{-}\mu\text{m}$ root-mean-square roughness height. The alternating ablation layers were 0.5080 cm thick and were fabricated from asbestos fibers which were impregnated with a phenolic resin and compression-molded into the desired shape. Details concerning their composition, fabrication, and thermal properties can be found in reference 8.

The thermophysical properties of beryllium which are considered to be the most applicable to the material used in the Fire reentry package are presented in figures 8 to 11. The variation of specific-heat capacity and thermal conductivity with temperature (shown in figs. 8 and 9, respectively) was determined from a survey of the literature and is essentially the same as that recommended in reference 9. A fourth-degree polynomial equation which fits the specific-heat capacity curve to within 1 percent is given in figure 8. The variation of total hemispherical emittance with temperature is shown in figure 10. This curve was estimated from values of total normal emittance measured by the National Bureau of Standards on specimens of the beryllium used in the Fire reentry package. The spectral absorptance considered to be applicable to the beryllium calorimeter layers over the wavelength range from 0.04 to $5.00\text{ }\mu\text{m}$ is shown in figure 11. The portion of the curve between 0.058 and $2.1\text{ }\mu\text{m}$ was derived from spectral reflectance measurements made at room temperature on specimens polished to the same surface finish as the Fire calorimeters. Some of these measurements are published in reference 10.

Data sensing and instrumentation.- The forebody temperatures were obtained from plugs (temperature measuring stations) located along three radial rays in each of the three beryllium calorimeter layers as shown in figure 12. The plugs for which a complete heating rate analysis is presented in this report are shown blackened. The plugs shown crosshatched are those for which only the temperature-time data are presented in tabular form. Because of thermocouple malfunctions, no data are presented for the plugs shown as open circles. The plugs were small circular cylinders which were machined from the same batch of beryllium as the layers into which they were shrink-fitted. A sketch of the plug installations is shown in figure 13. The diameter of all plugs was 0.9525 cm. Although the thickness of the first and third beryllium layers was only 0.3048 cm, the depth of each plug was 0.5080 cm. This uniform plug depth was obtained by providing the thinner layers with 5.08-cm-diameter bosses on their rearward surface to accommodate the full plug depth as shown in figure 13(a).

Each plug contained four chromel-alumel thermocouples ($25.4\text{-}\mu\text{m}$ wire diameter) whose junctions were located at the nominal depths of 0.03, 0.18, 0.33, and 0.51 cm (0.010, 0.070, 0.130, and 0.200 in., respectively) from the forward heated surface. The

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actual individual thermocouple depths were measured at the time the junctions were welded to the core prior to assembly of the plugs; the measurements obtained are given in table I. The distance from the calorimeter face to the center of each thermocouple bead had an estimated error of less than ± 0.005 cm after the final installation. Error analysis calculations indicate that an uncertainty of this magnitude in the location of all four thermocouples in a given plug would result in a maximum error of 1.5 percent in the calculated local heating rate.

A sketch of a typical thermocouple installation is shown in figure 14. Each core containing four thermocouples was press-fitted into a protecting sleeve. This assembly was then shrink-fitted into the beryllium calorimeter layer. In this manner a total of 144 thermocouples were installed in the three beryllium layers. Approximately 72 percent of these thermocouples functioned properly during reentry. Preflight attrition, due largely to broken wires suffered in the several matings of the forebody with the afterbody, accounted for approximately one-half of the bad thermocouples. Other details concerning the thermocouple installations and considerations involved in the design of the beryllium calorimeters are presented in references 11 and 12.

Each thermocouple output voltage was sampled sequentially at the rate of 10 samples per second by the use of a pulse-duration-modulation commutator. Certain critical thermocouples were double-commutated in order to obtain a sampling rate of 20 samples per second during the peak heating period. The signals from the commutator were telemetered to the ground by a real-time transmitter. They were also recorded on a tape loop in a tape recorder. After about a 42-second delay, the data from the tape were telemetered by a second or delay-time transmitter system, and the tape was erased. On emergence from radio-frequency blackout, the erase-and-record function of the tape recorder was canceled and the delay transmitter repeatedly broadcasted the 42-second cycle of data obtained prior to emergence from blackout. By these means, the data for the heat-pulse period (most of which occurs during blackout) were obtained. Four complete playbacks of the data were obtained prior to impact of the reentry package. There were no data dropout periods.

The overall accuracy of the telemetry system is estimated to be equal to or better than 2 percent of full scale (30° K for the forebody temperature data). Comparison of the data obtained from the real-time link prior to blackout with that which was passed through the tape recorder system and transmitted by the delay-time link indicates that 50 to 75 percent of the noise and scatter exhibited by the data originated in the delay-time system. The data scatter bands were evaluated by calculating the root-mean-square deviation from the mean (standard deviation) for representative time periods. The standard deviation of the real-time data obtained prior to and immediately after blackout

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varied from 4.3° K to 8.4° K whereas that for the playbacks of the delay-time data obtained during blackout varied from 14.9° K to 22.7° K.

DATA REDUCTION AND SMOOTHING

Data Reduction

As noted previously, the reentry package forebody temperatures were sensed by thermocouples whose hot junctions were located in the three beryllium calorimeter layers. The cold junctions of the thermocouple circuits were established at a point inside the reentry package and remained at an essentially constant reference temperature of 300° K as indicated by reference thermistors. The thermocouple voltages were sampled at the rate of 10, and in some cases 20, samples per second and the data were relayed to the ground in the form of a commutated pulse-duration-modulated signal. Since there were no data dropout periods, this signal was directly decommutated by machine and converted to temperature values by the use of the National Bureau of Standards (NBS) thermocouple wire calibration tables. The use of the standard wire calibration tables was justified by the use of good quality chromel-alumel thermocouple wire which was specified to have a deviation from NBS standard wire calibration equal to or less than $\pm 2^{\circ}$ K up to 550° K and a deviation of ± 0.375 percent at temperatures above 550° K.

A continuous signal from an onboard time-code generator was transmitted simultaneously with the primary data. This signal indicated that there was some slowdown of the tape recorder during the playbacks of the data before impact. Since it was necessary to utilize the delay-time or playback data to cover the blackout period, a time calibration obtained from the time-code-generator signal was applied to the decommutated data. The accumulative time adjustment varied from 0 to approximately 0.5 second over the 40-second period of sensible heating and did not affect the validity of the basic temperature data.

Data Smoothing

The basic temperature-time data exhibited a temperature scatter band which was generally around $\pm 30^{\circ}$ K. This scatter, which in most cases appeared to be randomly distributed, is believed to be primarily introduced in the delay-time recording and transmission system and in the process of decommutating the raw telemetry signal. Because of the magnitude of the scatter, it was necessary to smooth the basic data before applying it to heating rate calculations.

The data smoothing was accomplished in a manner similar to that utilized for the Fire I results reported in reference 3. The procedure consisted of manually fairing a

smooth curve through the scattered temperature-time data points and then fitting this curve with a sixth-degree polynomial equation whose coefficients were determined by the method of Chebyshev polynomials. (See, for example, ref. 13.) The resultant polynomial expressions for the local temperature T as a function of time t were of the form

$$T = A_0 + A_1 t + A_2 t^2 + A_3 t^3 + A_4 t^4 + A_5 t^5 + A_6 t^6$$

where the coefficients A_i were constant with respect to time for each of the three data periods. These algebraic expressions have been used in the forebody heating analysis in lieu of the actual scattered data points.

CALORIMETER HEATING ANALYSIS

The method used to calculate the forebody heating rates from the basic temperature-time data was essentially the same as that used for the Fire I reentry experiment. This method (described in detail in ref. 3) assumed that the thermal response of a beryllium layer in the vicinity of any given calorimeter plug was essentially that of a slab heated uniformly at one surface. This assumption implies that any radial heat conduction from the plug could be neglected and that the transient heat conduction was one-dimensional, depthwise, from the forward heated surface to the rearward insulated surface.

The problem was to determine the local surface heating rate which produced the known temperatures in a given beryllium plug. This problem is generally referred to as the inverse problem or a temperature-to-heat-flux inversion. In the analysis of the Fire data, a transient solution is used which relies heavily on techniques of curve fitting the basic temperature data. The solution accounts for variable material properties and yields a closed-form analytical expression for the local surface heat flux at any given instant of time.

For a given calorimeter plug, a general heat balance equation can be written in terms of the instantaneous heating rates as (see fig. 15)

$$\dot{q}_c(t) + \alpha \dot{q}_r(t) = \dot{q}_s(t) + \dot{q}_{em}(t) + \dot{q}_{ob}(t) \quad (1)$$

where

$$\dot{q}_s(t) = \int_0^L \rho c \frac{\partial T}{\partial t} dx \quad (2)$$

is the rate of heat storage in the plug,

$$\dot{q}_{\text{em}}(t) = \epsilon \sigma T_0^4 \quad (3)$$

is the rate at which heat is emitted to space from the forward exposed surface, and $\dot{q}_{\text{ob}}(t)$ is the heat flux through the rear surface of the plug.

Equation (1) indicates that in order to maintain a heat balance, the total heat input $\dot{q}_c + \alpha \dot{q}_r$ must equal the heat stored in the plug plus the total heat output. It can be seen that the evaluation of the instantaneous calorimeter heating rate at a given plug location consists simply of the evaluation and summation of the individual terms on the right-hand side of equation (1) for the given instant of time.

The heat storage term given by equation (2) was evaluated by forming an analytical expression for the integrand as a function of depth x and integrating directly with respect to x . Although the density ρ of beryllium was taken to be constant (1.85×10^{-3} kg/cm³), the variation of specific heat capacity c with temperature was accounted for by the use of a fourth-degree polynomial

$$c(T) = \sum_{i=0}^{i=4} d_i T^i \quad (4)$$

which represented the curve shown in figure 8 to within 1 percent over the temperature range from 222° K to 1558° K (melting point). The coefficients used in equation (4) are given in figure 8. The smoothing procedure used on the Fire temperature data yielded sixth-degree polynomial expressions for the local temperature T as a function of time t . For a given calorimeter plug, the temperature-time history curves for the four thermocouples located at the depths x_j were given by

$$T(x_j, t) = \sum_{i=0}^{i=6} A_{ij} t^i \quad (j = 1, 2, 3, 4) \quad (5)$$

Differentiating equation (5) with respect to time yields

$$\frac{\partial}{\partial t} T(x_j, t) = \sum_{i=0}^{i=6} i A_{ij} t^{i-1} \quad (j = 1, 2, 3, 4) \quad (6)$$

For any chosen instant of time $t = t_k$, equations (4), (5), and (6) can be used to calculate four values of the integrand of equation (2) corresponding to the thermocouple depths x_j . An analytical expression for the integrand as a function of x was obtained by curve fitting these four values with a cubic polynomial. This cubic polynomial in x was then

integrated between the limits $x = 0$ and $x = L$ to obtain an expression for $\dot{q}_s(t)$ which could be readily evaluated for any $t = t_k$.

In evaluating the rate of heat emission given by equation (3), the instantaneous surface temperature $T_0 = T(0,t)$ was obtained by a linear depthwise extrapolation of the temperature values indicated by the first two thermocouples in any given plug. Since the extrapolation distance was only approximately 0.03 cm and since \dot{q}_{em} was generally much less than 10 percent of the value of \dot{q}_s , the error introduced by the linear extrapolation procedure was negligible. In equation (3), σ is the Stefan-Boltzmann constant and $\epsilon = \epsilon(T_0)$ is the total hemispherical emittance of the beryllium surface. An estimate of the variation of ϵ with temperature is shown in figure 10.

The heat flux through the rear surface of a given plug was approximated by the expression

$$\dot{q}_{ob}(t_k) = -\frac{k(T_4 - T_3)}{36(x_4 - x_3)} \quad (7)$$

where the subscripts 3 and 4 refer to values at the last two thermocouple depths in each plug. The thermal conductivity $k = k(T_4)$ of beryllium is a function of the rear surface temperature $T(x_4, t_k)$ and is shown in figure 9. The multiplying factor 1/36 in equation (7) was used to approximate the slope of the temperature distribution curve at the rear surface $x = L$ from the known straight-line slope between the last two thermocouple depths. This factor was arbitrarily chosen after examination of the results of a number of machine calculations used to predict the temperature distributions and after examination of depthwise fairings of the smoothed experimental data. Since the rear surface of any beryllium plug was essentially insulated, the heat flux out the back was very small relative to that stored in the plug and could have been neglected with little error.

It can be seen that the calorimeter heating rate $\dot{q}_c + \alpha\dot{q}_r$ at $t = t_k$ is determined by the sum of the values obtained from equations (2), (3), and (7). The greatest source of error in this method lies in the manual fairing and curve fitting of the basic temperature data. The heat storage term (eq. (2)), which accounts for over 95 percent of the calorimeter heating rate, varies almost directly as the slopes of the temperature-time curves. Various fairings of the data have indicated that the calculated heating rates could be in error by as much as 10 percent during the peak heating period because of extreme variations in fairing. Errors in the calculated heating rates due to the maximum estimated error in thermocouple locations were determined to be less than 1.5 percent.

The value of \dot{q}_{em} determined by equation (3) varied from 0 to 18 watts/cm² as the calorimeter surface temperature rose to the melting point. This term accounted for approximately 3 percent of the calorimeter heat flux during the first experimental period and less than 2 percent at peak heating. The maximum value estimated for the heat loss through the rear surface of the calorimeter \dot{q}_{ob} (eq. (7)) was approximately 8 watts/cm².

RESULTS AND DISCUSSION

Basic Temperature Data

The forebody temperature data measured during the three experimental periods of the Fire II reentry are presented in tables II, III, and IV. The temperature data are tabulated against the total elapsed time from launch. The elapsed time from launch until the beginning of reentry (121.92-km altitude) was 1617.75 seconds. The data are presented for every thermocouple that functioned properly during reentry. It is noted that certain thermocouples began functioning properly during the early portion of their respective experimental periods but were lost or malfunctioned before the melting point of beryllium (1558° K) was reached.

In order to illustrate the quality of the basic data, the temperature-time histories are also plotted in figures 16 to 18 for the plugs for which heating rates have been calculated. These plots include one plug at each of the four radial stations on each beryllium calorimeter layer. The temperatures indicated by all four thermocouples in a given plug are shown on the same plot for comparison. The solid curves are plots of the sixth-degree polynomials used to smooth and fit the scattered data points. The polynomial expressions were used in the heating rate calculations.

In two cases (see figs. 16(c) and 17(a)), the loss of thermocouples rather early in their respective experimental period necessitated an extrapolation of the data in order to make full use of the data for other thermocouples in the given plug. In these cases, the extrapolation was guided by the response of corresponding thermocouples in nearby plugs where possible. In the cases of the plugs located on the rims ($s/R = 1.0$) of the calorimeter layers (see figs. 16(d), 17(d), and 18(d)), the response was low and essentially no depthwise discrimination could be made between thermocouples. In these cases a single curve was used to represent the data for all four thermocouples.

The general shape of the temperature-time history of the first beryllium layer is indicated in figure 16. The data indicate that the exposed surface of the calorimeter reached its melting temperature (1558° K) at $t = 1640$, approximately 22 seconds after the start of reentry. At approximately $t = 1642.5$ seconds, the second beryllium layer was exposed. As shown by figure 17, this layer provided approximately 2.5 seconds of clean experiment time before surface melting began. The third beryllium layer was

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exposed at approximately $t = 1648.1$ seconds and figure 18 indicates that the exposed surface of this layer did not reach its melting temperature before the end of the heat pulse.

As mentioned previously, bosses (shown in fig. 13(a)) were machined on the rear surface of the first and third calorimeter layers. These bosses were used to increase the calorimeter plug depth to 0.508 cm from the nominal layer thickness of 0.3048 cm. Because of this difference in thickness, it is reasonable to conclude that the temperature in the thin regions of the first and third beryllium layers increased at a slightly more rapid rate than that of the thicker calorimeter plugs. Three-dimensional (axisymmetric) heat-conduction calculations have been made to estimate the effect of the bosses. These calculations have indicated that, during the first experimental period, the temperatures measured are from 3 to 6 percent higher than those that would be measured by the same calorimeter plug in a beryllium layer which was of a uniform thickness equal to the full plug depth.

Body motions which occurred during the Fire II reentry were generally very small. The maximum angular excursion during the first experimental period was less than 1° . Although slightly larger body motions were experienced during the second and third experimental periods (maximum excursion of approximately 5° during the second period and 11° during the third period), comparison of the various temperature-time histories available for each calorimeter layer indicated no local hot spots and a relatively flat temperature distribution over the forebody at any given time.

Forebody Calorimeter Heating Rates

The experimental heating rates which were inferred from the basic temperature-time data for the Fire II reentry are shown in figure 19. The term "calorimeter heating rate" refers to the sum of the convective heating and that portion of the radiative heating which was absorbed by the beryllium calorimeters. The maximum calorimeter heating rate was approximately 1140 watts/cm² near the stagnation point ($s/R = 0.10$). It is estimated that this value could be varied by ± 50 watts/cm² depending upon the fairing of the basic temperature data. The sensible portion of the heat pulse occurred over a time period of approximately 30 seconds. The maximum heating rates occurred approximately 27 seconds after passing the initial reentry point at 121.92 km altitude. At the time of maximum heating, the reentry package was at an altitude of approximately 49 km and had a velocity of approximately 9920 m/sec.

A comparison of the experimental and predicted radial variation of heat flux over the forebody is shown in figure 20 for a time early in the heat pulse and for a time near peak heating. The predicted distributions were obtained from the analyses presented in references 14 to 17. Comparing figures 20(a) and 20(b) shows that the relative magnitude

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of the radial distribution for the Fire I and Fire II experiments reverses itself between the first and second experiment periods. This result is not believed to be particularly significant since the relatively flat distribution indicated by the Fire I results shown in figure 20(b) is probably due to the averaging effects of rather large body coning motions which occurred only during the second experiment period of that test. As reported in reference 18 for the Fire I reentry, the body coning half-angle jumped from around 1° during the first experiment period to approximately 33° during the second experiment period. Similar analyses for the Fire II reentry indicate that the maximum angle-of-attack excursion during the first experimental period varied from 0.5° to 1° whereas that for the second experiment period was only 5° . Thus the body motions were small and comparable during the period shown in figure 20(a), but considerably different near peak heating as shown in figure 20(b). The difference between the Fire I and Fire II results shown in figure 20(a) is within the accuracy with which the calorimeter heat flux could be determined (shown by the vertical bars on the data points) and is not considered significant. Within the limits of experimental accuracy, the distribution of heating rate across the spherical face of the beryllium calorimeter is seen to be fairly uniform.

The accumulative heat load experienced at the stagnation point of the Fire II reentry package is shown in figure 21. The curve shown represents a running time integration of a smooth curve faired through the three periods of experimental stagnation heating rate results (solid curve) shown in figure 19. It can be seen that the stagnation region absorbed approximately $13\ 000$ joules/cm 2 during the entire heat pulse.

Shown in figure 22 is a comparison of the stagnation heating rates experienced during the Fire I and Fire II reentries. In order to provide a more valid comparison, the Fire I results (shown as crosshatched bands to indicate range of uncertainty due to various data fairings) have been (1) adjusted for the rather large body motions which occurred and (2) scaled to the velocity and ambient density conditions of the Fire II experiment. In adjusting the Fire I results for body motions, the estimated angle-of-attack excursions were obtained from the simulation analyses reported in reference 18. The variation of stagnation-point heating rate with angle of attack was estimated from the data reported in references 4 and 19.

In scaling the Fire I results, it was necessary to separate the convective and radiative heating components by theoretically estimating the convective heating rate with the method of reference 20. The streamwise velocity gradient at the stagnation point for the relatively blunt spherical-segment shape of the Fire forebody was estimated by the use of the experimental correlation results presented in reference 21. The use of the bluntness correlation of reference 21 is a refinement of the Newtonian approximation used in the previous convective heating calculations presented in references 3 and 6. The theoretically calculated convective flux was subtracted from the experimental calorimeter

flux to obtain the absorbed radiative heat flux. The convective heating component was then scaled by the 0.5 power of the density ratio and the 3.15 power of the velocity ratio. The radiative heating component was scaled by the 1.55 power of the density ratio and the 9.0 power of the velocity ratio. The choice of scaling exponents is discussed in reference 6. The scaled Fire I results presented herein have been updated from those presented in reference 6 to account for recent trajectory refinements. No attempt has been made to refine the particular scaling procedure used since it is believed to provide a reasonable adjustment for the differences in the reentry trajectories and atmospheric conditions for the Fire I and Fire II reentries. It may be concluded from figure 22 that the results of the Fire I and Fire II experiments are generally consistent.

Figure 23 shows a comparison of the experimental calorimeter heating rate and theoretically predicted convective and calorimeter heating rates for the Fire II reentry. Again, the convective heating rate was computed by the method of reference 20. The discontinuities in the convective heating prediction are associated with the combined effects of (1) change in nose radius and (2) consideration of the cold wall temperature when the calorimeter layer is exposed. Figure 23 indicates that the theoretically predicted convective heating rate closely agrees with the experimental calorimeter results (solid curve) during all but the middle 12 seconds of the heat pulse, where the radiative heating absorbed by the calorimeter becomes an important contributor. At peak heating the absorbed radiation is indicated to provide approximately 40 percent of the calorimeter heating rate. The equilibrium radiative heating component of the theoretical calorimeter heating rate was estimated with the latest available radiation graphs given in reference 22 which include atomic line radiation in the ultraviolet as well as in the infrared regions of the spectrum. Nonequilibrium radiation was estimated from the results presented in reference 23. Self absorption in the gas cap was accounted for only to the extent that it is included in the graphs of reference 22. The shock standoff distance was estimated from the density ratio and nose radius by the method of reference 24. The specific details and procedures used in the radiation calculations are described in reference 4. It should be noted that the theoretical predictions do not account for probable attenuating effects of radiative cooling and associated radiative-convective coupling effects. The absorptance α of beryllium was taken to be 0.54 for all radiation above a wavelength of $0.2 \mu\text{m}$, 0.75 for atomic line radiation below $0.2 \mu\text{m}$, and 0.94 for all other radiation in the vacuum ultraviolet. Figure 23 also indicates that the theoretically predicted calorimeter heating rate is in rough general agreement with the measured results except in the region of maximum heating rate, which is overpredicted by approximately 200 watts/cm^2 .

CONCLUDING REMARKS

Measurements of the heating attendant to reentry into the earth's atmosphere of a large-scale blunt body at an initial velocity of 11.35 km/sec have been obtained from the Fire II ballistic reentry test. Temperature-time histories measured on three successively exposed beryllium calorimeter heat shields have been analyzed to determine the heating rates, which represent the sum of convective heating and absorbed radiation. The calorimeter measurements, along with the surface absorptivity and other material properties and details of the reentry trajectory and atmosphere, are presented in this paper. It is expected that these basic data, in conjunction with results from other onboard experiments reported separately, will be very useful in assessing the accuracy of reentry heating predictions for this severe environment. As a result of the calorimeter heating measurements, the following remarks are presented:

1. The concept of exposing successive cool calorimeters to the reentry heating environment, thereby permitting measurements to be made during several portions of the reentry, was successfully demonstrated. As a result of this technique, the Fire II calorimeter experiments provided data for approximately 85 percent of the 40-second heat pulse.
2. A maximum calorimeter heating rate of 1140 watts/cm^2 was indicated near the center of the heat shield. The corresponding altitude and velocity were approximately 49 km and 9.92 km/sec. The total accumulated heat load in the stagnation region was approximately $13\,000 \text{ joules/cm}^2$.
3. A calculation of the stagnation-point convective heating, by using available theory, closely agrees with the calorimeter results for the stagnation area during all but the middle 12 seconds of the heat pulse, where the radiative heating absorbed by the calorimeter becomes an important contributor. At peak heating the absorbed radiation is indicated to provide approximately 40 percent of the calorimeter heating rate.
4. A theoretical estimate of the calorimeter heating pulse based on available prediction methods, which, however, neglect radiation cooling and associated coupling effects, is in rough general agreement with the measured results except in the region of maximum heating rate, which is overpredicted by approximately 200 watts/cm^2 .
5. The Fire II calorimeter data are consistent with the Fire I results when the differences in reentry velocity and ambient density are taken into account.
6. Within the limits of experimental accuracy, the distribution of heating rate across the spherical face of the beryllium calorimeter is seen to be fairly uniform.

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TABLE I.- DEPTH OF THERMOCOUPLES IN BERYLLIUM CALORIMETER LAYERS

Beryllium layer	Radial location, s/R	Azimuth angle, ϕ , deg	Thermocouple depths, x, cm			
1	0.09	33.75	0.0272	0.1806	0.3312	-----
		146.25	.0325	.1824	.3358	0.5080
		258.75	.0277	.1773	.3320	.5080
	0.55	33.75	0.0315	0.1831	0.3350	0.5080
		146.25	.0302	-----	.3376	-----
		258.75	.0300	.1852	.3358	.5080
	0.89	33.75	-----	0.1880	0.3403	0.5080
		146.25	0.0305	.1824	.3399	-----
		258.75	.0363	.1897	.3414	.5080
	1.00	28.00	0.0328	0.1834	0.3350	0.5080
		152.00	.0300	.1801	.3332	.5080
		242.00	.0295	.1783	-----	.5080
2	0.10	146.25	0.0356	0.1880	0.3404	0.5080
		33.75	0.0300	0.1829	0.3353	0.5080
		146.25	.0315	.1829	.3353	-----
	0.90	33.75	-----	-----	0.3355	-----
		146.25	0.0284	0.1842	.3330	0.5080
		28.00	0.0310	-----	0.3358	0.5080
	1.00	152.00	.0318	0.1875	.3399	.5080
		242.00	.0292	.1819	.3312	.5080
		28.00	0.0318	-----	-----	-----
3	0.10	146.25	.0282	0.1852	-----	0.5080
		242.00	.0302	.1867	0.3325	.5080
		28.00	-----	0.1814	0.3366	0.5080
	0.57	242.00	0.0330	.1880	.3376	.5080
		28.00	-----	0.1839	-----	-----
		146.25	.0302	-----	0.3325	0.5080
	0.87	242.00	.0356	.1880	.3386	.5080
		28.00	0.0315	0.1831	-----	0.5080
		146.25	-----	.1814	0.3363	.5080
	1.00	242.00	.0300	.1824	.3396	.5080

TABLE II. - TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER

(a) $s/R = 0.09; \phi = 33.75^\circ$

Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$		
	0.0272 cm	0.1806 cm	0.3312 cm		0.0272 cm	0.1806 cm	0.3312 cm		0.0272 cm	0.1806 cm	0.3312 cm
1624.05	314	318	---	1629.70	367	428	424	1635.02	----	694	677
1624.15	324	334	318	1629.80	382	415	412	1635.12	----	708	678
1624.25	---	---	---	1629.90	434	422	422	1635.21	----	702	---
1624.34	318	---	311	1630.00	443	441	432	1635.31	----	715	700
1624.44	315	338	334	1630.09	441	445	441	1635.41	----	724	705
1624.54	324	333	333	1630.19	452	---	537	1635.51	----	749	733
1624.64	---	325	340	1630.29	416	---	413	1635.61	----	757	749
1624.74	318	---	318	1630.39	471	454	450	1635.71	----	759	733
1624.84	319	315	315	1630.49	424	438	420	1635.80	----	797	784
1624.94	309	---	343	1630.59	449	440	440	1635.90	----	797	784
1625.04	---	309	319	1630.69	484	481	477	1636.00	----	774	756
1625.24	324	324	343	1630.79	478	486	481	1636.10	----	834	773
1625.34	339	---	350	1630.88	---	452	446	1636.20	----	843	816
1625.44	330	351	333	1630.98	466	455	453	1636.29	----	839	808
1625.54	325	331	354	1631.08	501	499	481	1636.39	----	834	812
1625.64	338	328	348	1631.18	449	456	456	1636.49	----	827	804
1625.74	343	343	348	1631.28	471	475	471	1636.59	----	902	846
1625.83	340	340	356	1631.38	495	478	476	1636.69	----	857	830
1625.93	328	343	---	1631.48	499	484	459	1636.79	----	881	865
1626.13	319	354	341	1631.57	494	470	467	1636.88	----	885	855
1626.23	336	355	330	1631.67	479	---	---	1636.98	----	874	883
1626.33	350	361	---	1631.77	501	503	507	1637.08	----	929	890
1626.43	331	338	344	1631.87	503	500	498	1637.28	----	942	920
1626.53	333	343	345	1631.97	519	522	464	1637.37	----	1007	965
1626.63	---	334	328	1632.07	525	514	505	1637.57	1035	1004	984
1626.73	333	348	354	1632.16	539	---	509	1637.67	1060	1025	964
1626.83	346	365	353	1632.26	522	525	517	1637.77	1052	1018	977
1626.93	344	356	371	1632.36	516	---	497	1637.86	1088	1046	1001
1627.03	335	343	359	1632.46	524	526	526	1637.96	1095	1045	1030
1627.22	367	---	---	1632.56	522	533	508	1638.06	1163	1095	1045
1627.32	---	351	---	1632.76	530	552	539	1638.16	1163	1102	1039
1627.42	338	354	350	1632.85	551	535	543	1638.26	1166	1099	1066
1627.52	357	385	376	1632.95	565	538	543	1638.35	1202	1135	1090
1627.62	364	370	376	1633.05	---	569	558	1638.45	1214	1122	1107
1627.72	357	364	357	1633.15	---	572	548	1638.55	1243	1146	1100
1627.82	341	377	361	1633.25	---	584	561	1638.65	1232	1169	1089
1627.92	---	364	372	1633.35	---	575	563	1638.75	1276	1198	1147
1628.02	379	---	383	1633.44	---	566	568	1638.84	----	1171	1114
1628.12	387	---	395	1633.54	---	592	579	1638.94	1289	1240	1157
1628.21	367	383	405	1633.64	---	567	575	1639.04	1355	1241	---
1628.31	370	378	378	1633.74	---	624	605	1639.14	1355	1289	1213
1628.41	370	---	384	1633.84	---	619	606	1639.24	1404	1311	1218
1628.51	376	410	393	1633.94	---	606	596	1639.33	1415	1322	1229
1628.61	383	421	---	1634.03	---	604	609	1639.43	1437	1328	1289
1628.71	---	---	379	1634.13	---	625	628	1639.53	1443	1328	1271
1628.81	381	403	409	1634.23	---	647	624	1639.63	1489	1384	1307
1628.91	378	396	399	1634.33	---	625	617	1639.73	1499	1368	1313
1629.01	407	---	---	1634.43	---	643	629	1639.82	1513	1411	1357
1629.11	393	---	418	1634.53	---	647	630	1639.92	1417	1345	---
1629.20	385	409	401	1634.62	---	659	637	1640.02	1444	1377	---
1629.30	376	402	402	1634.72	---	673	661	1640.12	1465	1381	1400
1629.40	368	407	401	1634.82	---	686	677	1640.22	1465	1381	1417
1629.50	378	407	418	1634.92	---	690	---	1640.31	1465	1381	1417
1629.60	400	416	426								

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(b) $s/R = 0.09$; $\phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$		
	0.0325 cm	0.1824 cm	0.3358 cm	0.5080 cm		0.0325 cm	0.1824 cm	0.3358 cm	0.5080 cm		0.1824 cm	0.3358 cm	0.5080 cm
1624.05	314	---	329	---	1629.70	420	396	424	424	1635.12	702	710	669
1624.15	300	321	334	---	1629.80	425	403	---	406	1635.21	----	684	667
1624.25	300	300	303	315	1629.90	428	428	420	412	1635.31	720	717	681
1624.34	300	300	---	300	1630.00	432	432	421	427	1635.41	734	699	681
1624.44	325	319	334	344	1630.09	441	441	450	439	1635.51	727	719	689
1624.54	335	329	329	333	1630.19	440	446	428	420	1635.61	780	765	718
1624.64	336	321	340	300	1630.29	422	427	---	413	1635.71	754	740	705
1624.74	330	315	330	339	1630.39	445	450	462	454	1635.80	751	749	717
1624.84	309	315	---	325	1630.49	445	435	438	453	1635.90	792	754	733
1624.94	328	330	349	330	1630.59	454	446	460	446	1636.00	801	764	737
1625.04	---	315	325	303	1630.69	---	---	467	464	1636.10	795	773	756
1625.24	324	330	321	340	1630.79	---	---	483	478	1636.20	814	----	789
1625.34	335	350	339	350	1630.88	463	469	461	449	1636.29	842	808	772
1625.44	330	341	348	315	1630.98	457	533	455	449	1636.39	848	820	795
1625.54	331	331	341	329	1631.08	484	478	487	478	1636.49	842	823	794
1625.64	344	350	344	334	1631.18	487	---	477	477	1636.59	879	864	825
1625.74	348	345	339	343	1631.28	483	463	463	443	1636.69	880	846	830
1625.83	346	338	344	350	1631.38	495	478	484	476	1636.79	906	887	839
1625.93	328	336	324	343	1631.48	499	495	459	482	1636.88	899	885	857
1626.13	354	331	329	344	1631.57	478	478	530	481	1636.98	919	893	853
1626.23	349	351	357	345	1631.67	518	503	506	500	1637.08	929	918	871
1626.33	350	346	320	331	1631.77	495	513	501	489	1637.28	982	930	883
1626.43	353	359	334	356	1631.87	508	506	511	478	1637.37	1009	992	944
1626.53	---	343	345	335	1631.97	522	510	506	492	1637.57	1035	987	941
1626.63	353	338	340	325	1632.07	534	525	508	487	1637.67	1051	1007	984
1626.73	354	364	345	354	1632.16	533	530	518	518	1637.77	1040	1006	969
1626.83	---	371	359	359	1632.26	517	514	494	490	1637.86	1052	1031	993
1626.93	353	359	368	353	1632.36	502	---	500	538	1637.96	1077	1041	990
1627.03	339	365	335	325	1632.46	547	530	521	500	1638.06	1116	1083	1033
1627.22	362	373	359	371	1632.56	525	525	508	508	1638.16	1099	1057	1002
1627.32	361	345	351	345	1632.78	---	530	524	1638.26	1131	1075	1038	
1627.42	---	378	354	344	1632.85	543	549	532	1638.35	----	1114	1081	
1627.52	378	372	372	360	1632.95	538	549	527	1638.45	1145	1087	1056	
1627.62	373	376	382	339	1633.05	558	560	534	1638.55	1155	1111	1056	
1627.72	357	349	367	361	1633.15	550	569	536	1638.65	1169	1109	1057	
1627.82	387	361	367	393	1633.25	565	553	542	1638.75	1198	1153	1108	
1627.92	364	361	372	370	1633.35	566	556	544	1638.84	----	1123	1072	
1628.02	371	406	371	362	1633.44	568	568	566	1638.94	1217	1177	1108	
1628.12	359	356	374	368	1633.54	581	---	554	1639.04	1248	1213	1137	
1628.21	373	---	---	---	1633.64	594	578	561	1639.14	1267	1209	1147	
1628.31	381	378	372	381	1633.74	618	591	591	1639.24	1287	1247	1160	
1628.41	407	399	390	390	1633.84	600	590	592	1639.33	1321	1269	1190	
1628.51	387	399	387	387	1633.94	600	600	---	1639.43	1353	1269	1208	
1628.61	415	408	---	415	1634.03	609	613	571	1639.53	1355	1328	1223	
1628.71	418	403	403	400	1634.13	614	619	600	1639.63	1364	1328	1219	
1628.81	401	401	407	---	1634.23	629	606	608	1639.73	1387	1326	1243	
1628.91	399	393	402	408	1634.33	619	605	597	1639.82	1415	1316	1227	
1629.01	407	399	389	399	1634.43	635	635	594	1639.92	1431	1364	1229	
1629.11	424	413	418	418	1634.53	---	641	639	1640.02	1458	1414	1291	
1629.20	407	397	---	389	1634.62	665	659	618	1640.12	1451	1395	1273	
1629.30	---	432	408	388	1634.72	650	659	643	1640.22	1476	1428	1315	
1629.40	419	401	422	---	1634.82	661	654	654	1640.31	1433	1309	1308	
1629.50	413	418	418	409	1634.92	707	688	665	1640.41	1440	1316	1316	
1629.60	428	436	416	428	1635.02	690	674	658					

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(c) $s/R = 0.09$; $\phi = 258.75^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$			
	0.0277 cm	0.1773 cm	0.3320 cm	0.5080 cm		0.0277 cm	0.1773 cm	0.3320 cm	0.5080 cm		0.0277 cm	0.1773 cm	0.3320 cm	0.5080 cm
1624.05	300	---	329	---	1629.70	406	408	412	424	1635.12	675	684	684	656
1624.15	324	328	321	---	1629.80	421	400	421	409	1635.21	702	691	667	---
1624.25	303	309	315	305	1629.90	426	418	428	414	1635.31	745	722	698	---
1624.34	318	305	300	318	1630.00	418	435	429	421	1635.41	736	707	684	689
1624.44	338	334	331	338	1630.09	---	---	---	441	1635.51	751	716	---	689
1624.54	333	329	314	327	1630.19	440	436	420	431	1635.61	763	734	720	724
1624.64	318	340	318	321	1630.29	427	427	425	410	1635.71	759	754	724	708
1624.74	303	321	314	330	1630.39	454	448	448	433	1635.80	778	751	---	725
1624.84	344	313	---	---	1630.49	441	456	445	432	1635.90	803	780	776	725
1624.94	353	340	330	328	1630.59	460	460	457	443	1636.00	801	769	743	733
1625.04	---	---	309	---	1630.69	477	481	467	427	1636.10	838	801	776	743
1625.24	345	330	340	336	1630.79	472	489	486	472	1636.20	853	817	786	770
1625.34	329	324	318	314	1630.88	477	466	457	443	1636.29	859	828	800	---
1625.44	333	339	324	324	1630.98	477	466	457	457	1636.39	854	829	810	779
1625.54	---	335	338	348	1631.08	469	484	495	467	1636.49	871	829	817	779
1625.64	344	348	325	---	1631.18	463	467	467	456	1636.59	899	879	849	825
1625.74	343	343	348	343	1631.28	461	463	463	446	1636.69	916	885	836	836
1625.83	344	346	350	338	1631.38	484	493	476	476	1636.79	935	881	862	837
1625.93	330	339	334	---	1631.48	499	464	476	470	1636.88	930	883	860	836
1626.13	357	---	338	---	1631.57	481	456	492	470	1636.98	946	885	850	847
1626.23	343	355	343	343	1631.67	---	518	514	---	1637.08	960	912	898	840
1626.33	331	327	341	331	1631.77	---	466	---	475	1637.28	991	939	911	899
1626.43	368	344	359	365	1631.87	484	478	484	469	1637.37	1031	---	953	929
1626.53	345	335	333	---	1631.97	516	502	502	502	1637.57	1035	972	964	927
1626.63	350	344	340	344	1632.07	516	514	502	505	1637.67	1045	990	958	921
1626.73	364	357	357	348	1632.16	527	527	503	507	1637.77	---	---	974	934
1626.83	365	355	355	365	1632.26	522	506	531	506	1637.86	1066	1025	970	960
1626.93	362	383	368	362	1632.36	500	497	500	536	1637.96	1085	1027	995	955
1627.03	349	345	335	339	1632.46	509	503	509	492	1638.06	1134	1035	1024	1004
1627.22	---	379	385	373	1632.56	527	510	---	510	1638.16	1126	1072	1091	1008
1627.32	357	339	345	357	1632.76	550	527	515	521	1638.26	1131	1069	994	1006
1627.42	364	348	376	356	1632.85	538	535	532	513	1638.35	1187	1129	1045	1021
1627.52	379	366	379	366	1632.95	538	540	538	510	1638.45	1193	1112	1062	1031
1627.62	---	373	384	376	1633.05	545	536	549	534	1638.55	1206	1146	1088	1065
1627.72	379	367	367	351	1633.15	572	577	563	542	1638.65	1214	1157	1085	1047
1627.82	361	367	348	341	1633.25	565	545	540	553	1638.75	1236	1171	1096	1084
1627.92	374	370	361	367	1633.35	575	558	556	---	1638.84	1229	1146	1076	1068
1628.02	385	377	388	377	1633.44	581	---	566	568	1638.94	1328	1208	1136	1100
1628.12	374	393	368	365	1633.54	566	560	558	560	1639.04	1305	1223	1137	1149
1628.21	395	383	383	391	1633.64	563	556	544	---	1639.14	1351	1244	1177	1157
1628.31	393	378	399	370	1633.74	584	608	586	550	1639.24	1374	1250	1160	1179
1628.41	399	381	374	384	1633.84	608	598	588	590	1639.33	1433	1322	1243	1204
1628.51	393	390	396	387	1633.94	615	609	---	585	1639.43	1420	1301	1265	1202
1628.61	---	---	419	---	1634.03	615	607	601	580	1639.53	1495	1346	1272	1240
1628.71	412	379	406	406	1634.13	643	625	617	595	1639.63	1506	1353	1257	1277
1628.81	426	397	403	403	1634.23	626	597	581	---	1639.73	1520	1380	1295	1255
1628.91	405	408	390	381	1634.33	654	628	599	590	1639.82	1535	1381	1313	1276
1629.01	395	---	387	399	1634.43	631	624	607	605	1639.92	1428	1355	1324	1320
1629.11	413	413	413	415	1634.53	647	634	625	609	1640.02	1500	1364	1320	1320
1629.20	427	391	413	403	1634.62	665	637	626	624	1640.12	1560	1368	1351	1411
1629.30	410	406	402	406	1634.72	676	650	650	631	1640.22	1576	1376	1406	1407
1629.40	416	---	410	407	1634.82	683	650	646	643	1640.31	1580	1380	1295	1255
1629.50	407	403	407	413	1634.92	678	685	670	---	1640.41	1587	1381	1313	1276
1629.60	436	434	426	431	1635.02	705	677	684	653					

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(d) $s/R = 0.55; \phi = 33.75^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$			
	0.0315 cm	0.1831 cm	0.3350 cm	0.5080 cm		0.0315 cm	0.1831 cm	0.3350 cm	0.5080 cm		0.0315 cm	0.1831 cm	0.3350 cm	0.5080 cm
1624.15	328	---	324	324	1629.70	408	438	424	418	1635.02	712	677	664	674
1624.25	309	---	---	---	1629.80	412	409	415	421	1635.12	716	691	675	647
1624.34	343	321	333	339	1629.90	420	434	428	422	1635.21	729	----	675	678
1624.44	321	334	331	321	1630.00	441	427	424	424	1635.31	747	717	700	689
1624.54	333	320	339	335	1630.09	441	441	431	447	1635.41	744	726	694	684
1624.64	333	348	333	340	1630.19	446	428	---	442	1635.51	777	----	----	699
1624.74	321	343	321	318	1630.29	416	427	433	419	1635.61	800	755	744	728
1624.84	329	---	303	319	1630.39	460	454	---	454	1635.71	778	740	729	716
1624.94	328	340	346	340	1630.49	426	416	438	---	1635.80	803	776	751	736
1625.04	315	315	303	313	1630.59	454	454	452	434	1635.90	830	786	757	748
1625.24	343	340	334	334	1630.69	494	477	---	457	1636.00	808	----	750	737
1625.34	348	354	354	354	1630.79	492	483	---	---	1636.10	855	817	756	767
1625.44	341	341	320	351	1630.88	446	471	457	452	1636.20	864	822	811	778
1625.54	341	335	335	325	1630.98	455	433	453	455	1636.29	897	816	814	785
1625.64	356	348	319	344	1631.08	505	478	475	---	1636.39	890	831	810	795
1625.74	360	360	330	354	1631.18	481	453	453	439	1636.49	910	837	827	794
1625.83	344	353	346	350	1631.28	471	486	446	469	1636.59	928	870	855	846
1625.93	355	357	351	336	1631.38	501	482	478	487	1636.69	934	891	836	827
1626.13	---	341	354	335	1631.48	495	490	476	478	1636.79	958	887	842	820
1626.23	345	345	349	345	1631.57	497	464	470	467	1636.88	951	893	849	841
1626.33	359	364	355	373	1631.67	490	---	---	---	1636.98	----	883	860	841
1626.43	350	350	368	359	1631.77	507	513	510	501	1637.08	974	918	900	854
1626.53	361	343	355	345	1631.87	511	498	503	500	1637.28	1020	942	908	893
1626.63	344	350	340	331	1631.97	527	516	500	500	1637.37	1064	992	942	933
1626.73	360	364	366	364	1632.07	519	522	508	497	1637.57	1097	1045	984	958
1626.83	355	361	361	346	1632.16	533	524	535	513	1637.67	1093	1013	976	950
1626.93	377	368	362	377	1632.26	531	508	511	503	1637.77	1136	1026	974	942
1627.03	359	345	---	359	1632.36	525	506	511	497	1637.86	1140	1054	1028	976
1627.22	376	382	385	385	1632.46	535	507	513	492	1637.96	1173	1089	----	984
1627.32	367	351	---	348	1632.56	539	533	516	527	1638.06	1173	1109	1063	1030
1627.42	360	370	348	356	1632.76	544	541	---	533	1638.16	1239	1148	1072	1041
1627.52	370	376	357	376	1632.85	551	554	543	535	1638.26	1252	1137	1087	1034
1627.62	378	378	376	384	1632.95	559	559	559	532	1638.35	----	1198	1108	1078
1627.72	370	370	370	355	1633.05	587	560	554	551	1638.45	1292	1181	1118	1078
1627.82	367	361	351	367	1633.15	588	---	567	553	1638.55	1313	1210	1137	1114
1627.92	367	374	374	364	1633.25	591	561	553	550	1638.65	1331	1198	1132	1106
1628.02	379	385	397	397	1633.35	580	588	---	535	1638.75	1350	1240	1198	1169
1628.12	399	401	410	393	1633.44	590	577	573	535	1638.84	----	----	1146	----
1628.21	407	389	395	383	1633.54	598	590	577	573	1638.94	1396	1265	1198	----
1628.31	401	384	393	378	1633.64	586	---	---	556	1639.04	1402	----	----	1198
1628.41	395	374	384	401	1633.74	618	591	594	591	1639.14	1421	1316	1248	1221
1628.51	413	396	378	382	1633.84	617	592	598	590	1639.24	1425	1334	1264	1253
1628.61	---	---	428	401	1633.94	645	606	609	600	1639.33	1474	1346	1299	1252
1628.71	---	---	---	---	1634.03	628	609	596	594	1639.43	1506	1389	1328	1283
1628.81	397	415	409	387	1634.13	656	628	625	606	1639.53	1389	1305	1269	1269
1628.91	405	408	405	414	1634.23	658	637	631	614	1639.63	1414	1336	1307	1307
1629.01	377	410	419	383	1634.33	648	619	623	605	1639.73	1391	----	1334	1334
1629.11	427	418	413	427	1634.43	659	635	618	631	1639.82	1457	1368	1354	1354
1629.20	409	407	415	427	1634.53	675	641	636	660	1639.92	1478	1377	1417	1421
1629.30	406	408	406	400	1634.62	688	654	629	635	1640.02	1489	1417	1421	1435
1629.40	395	407	405	413	1634.72	698	667	654	643					
1629.50	421	397	387	421	1634.82	690	683	675	640	1640.22				
1629.60	434	412	400	414	1634.92	721	694	665	665					

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(e) $s/R = 0.55; \phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$		Time, sec	Temperature, °K, at $x =$		Time, sec	Temperature, °K, at $x =$	
	0.0302 cm	0.3376 cm		0.0302 cm	0.3376 cm		0.0302 cm	0.3376 cm
1624.05	329	---	1629.60	428	439	1634.92	721	685
1624.15	---	324	1629.70	414	432	1635.02	712	679
1624.25	300	300	1629.80	418	504	1635.12	705	675
1624.34	300	300	1629.90	432	434	1635.21	---	673
1624.44	300	---	1630.00	432	443	1635.31	726	695
1624.54	333	327	1630.09	---	436	1635.41	747	694
1624.64	300	336	1630.19	446	428	1635.51	755	719
1624.74	318	343	1630.29	416	416	1635.61	768	736
1624.84	313	313	1630.39	460	445	1635.71	761	716
1624.94	330	336	1630.49	438	445	1635.80	795	727
1625.04	300	313	1630.59	460	449	1635.90	789	738
1625.24	328	336	1630.69	498	470	1636.00	777	764
1625.34	341	350	1630.79	497	486	1636.10	812	754
1625.44	324	333	1630.88	471	432	1636.20	824	778
1625.54	335	329	1630.98	471	471	1636.29	851	783
1625.64	334	319	1631.08	475	490	1636.39	850	837
1625.74	360	354	1631.18	---	456	1636.49	871	810
1625.83	350	328	1631.28	481	457	1636.59	911	---
1625.93	345	336	1631.38	482	487	1636.69	922	840
1626.13	329	344	1631.48	501	501	1636.79	918	850
1626.23	360	355	1631.57	478	530	1636.88	936	830
1626.33	350	335	1631.67	518	---	1636.98	949	853
1626.43	356	371	1631.77	510	501	1637.08	966	887
1626.53	335	343	1631.87	500	500	1637.28	997	905
1626.63	331	344	1631.97	519	508	1637.37	1064	938
1626.73	339	360	1632.07	510	522	1637.57	1077	976
1626.83	343	353	1632.16	535	518	1637.67	1084	970
1626.93	362	368	1632.26	511	508	1637.77	1076	985
1627.03	351	343	1632.36	519	502	1637.86	1152	1011
1627.22	382	367	1632.46	518	547	1637.96	1169	1019
1627.32	357	335	1632.56	544	541	1638.06	1214	1057
1627.42	376	348	1632.76	530	533	1638.16	1197	1059
1627.52	366	344	1632.85	565	524	1638.26	1243	1072
1627.62	370	382	1632.95	554	541	1638.35	1267	1099
1627.72	367	357	1633.05	566	563	1638.45	1257	1101
1627.82	351	---	1633.15	572	548	1638.55	1304	1131
1627.92	387	364	1633.25	580	550	1638.65	1287	1116
1628.02	391	385	1633.35	---	563	1638.75	1323	1157
1628.12	377	387	1633.44	587	568	1638.84	1327	1135
1628.21	373	---	1633.54	581	566	1638.94	1369	1202
1628.31	366	381	1633.64	597	591	1639.04	1440	1207
1628.41	405	393	1633.74	613	580	1639.14	1458	1228
1628.51	384	393	1633.84	629	604	1639.24	1485	1277
1628.61	421	405	1633.94	617	596	1639.33	1509	1272
1628.71	406	---	1634.03	626	594	1639.43	1523	1296
1628.81	426	403	1634.13	648	617	1639.53	1535	1319
1628.91	390	399	1634.23	639	626	1639.63		1334
1629.01	401	401	1634.33	637	614	1639.73		1334
1629.11	413	418	1634.43	661	607	1639.82		1334
1629.20	397	409	1634.53	658	609	1639.92		1368
1629.30	414	396	1634.62	668	651	1640.02		1410
1629.40	419	407	1634.72	684	650	1640.12		1409
1629.50	415	418	1634.82	690	664	1640.22		1460

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(f) S/R = 0.55; $\phi = 258.75^\circ$

Time, sec	Temperature, °K, at x =				Time, sec	Temperature, °K, at x =				Time, sec	Temperature, °K, at x =			
	0.0300 cm	0.1852 cm	0.3358 cm	0.5080 cm		0.0300 cm	0.1852 cm	0.3358 cm	0.5080 cm		0.0300 cm	0.1852 cm	0.3358 cm	0.5080 cm
1624.05	329	---	---	---	1629.60	431	439	408	434	1634.92	710	690	----	685
1624.15	336	311	---	321	1629.70	434	420	412	432	1635.02	705	671	671	658
1624.25	309	300	305	300	1629.80	427	436	425	397	1635.12	689	661	667	669
1624.34	300	300	300	309	1629.90	428	432	428	420	1635.21	708	678	----	651
1624.44	321	313	331	325	1630.00	449	435	427	427	1635.31	750	736	715	681
1624.54	318	320	335	318	1630.09	---	445	433	---	1635.41	744	710	707	691
1624.64	348	336	310	310	1630.19	436	440	440	426	1635.51	768	----	725	738
1624.74	318	327	324	324	1630.29	425	416	419	419	1635.61	786	749	731	715
1624.84	325	309	309	309	1630.39	468	450	462	466	1635.71	761	729	724	710
1624.94	346	336	343	324	1630.49	453	447	426	438	1635.80	782	774	749	735
1625.04	---	303	303	303	1630.59	454	457	460	454	1635.90	832	805	761	735
1625.24	---	324	309	328	1630.69	491	484	467	464	1636.00	833	785	758	761
1625.34	350	329	309	324	1630.79	500	478	478	483	1636.10	821	793	770	767
1625.44	330	318	318	320	1630.88	469	446	446	505	1636.20	847	816	805	784
1625.54	338	344	331	325	1630.98	455	445	463	457	1636.29	863	822	820	791
1625.64	334	340	362	350	1631.08	499	481	487	481	1636.39	875	825	810	793
1625.74	357	343	345	351	1631.18	474	487	456	519	1636.49	859	840	815	788
1625.83	340	350	334	350	1631.28	477	469	467	461	1636.59	922	881	840	817
1625.93	351	334	348	334	1631.38	501	478	482	476	1636.69	926	883	846	840
1626.13	364	348	357	321	1631.48	516	470	484	472	1636.79	929	875	862	839
1626.23	355	366	343	360	1631.57	502	459	542	475	1636.88	----	885	857	851
1626.33	373	364	329	329	1631.67	---	---	---	---	1636.98	960	888	874	847
1626.43	374	353	374	344	1631.77	---	471	---	466	1637.08	983	912	884	873
1626.53	335	335	---	335	1631.87	500	467	489	464	1637.28	1002	953	916	905
1626.63	340	334	344	328	1631.97	524	502	497	492	1637.37	1062	1004	959	944
1626.73	354	364	348	354	1632.07	514	516	508	499	1637.57	1091	1030	992	929
1626.83	355	361	361	373	1632.16	541	527	515	513	1637.67	1087	1034	979	956
1626.93	---	---	368	374	1632.26	522	503	508	514	1637.77	1126	1032	977	948
1627.03	335	343	345	339	1632.36	---	508	508	491	1637.86	1130	1046	987	984
1627.22	379	371	373	367	1632.46	544	541	515	518	1637.96	1128	1059	1019	1035
1627.32	371	355	341	361	1632.56	533	514	510	516	1638.06	1152	1122	1035	1033
1627.42	350	370	364	370	1632.76	556	535	533	533	1638.16	1201	1120	1069	1033
1627.52	370	372	366	357	1632.85	543	545	541	532	1638.26	1243	1081	1058	1064
1627.62	384	343	382	378	1632.95	562	557	538	532	1638.35	1283	1157	1096	1075
1627.72	367	376	---	349	1633.05	560	525	536	531	1638.45	1251	1158	1103	1089
1627.82	361	379	351	371	1633.15	553	567	553	559	1638.55	1254	1187	1135	1100
1627.92	378	364	361	361	1633.25	565	561	550	559	1638.65	1308	1210	1130	1112
1628.02	383	379	379	365	1633.35	575	577	560	556	1638.75	1334	1208	1151	1114
1628.12	368	381	383	362	1633.44	587	568	566	558	1638.84	1330	----	1154	1126
1628.21	379	407	389	---	1633.54	577	585	568	577	1638.94	----	----	1187	1169
1628.31	381	395	381	370	1633.64	591	578	558	----	1639.04	1369	1265	1210	1192
1628.41	395	405	395	370	1633.74	610	599	603	594	1639.14	1402	1287	1248	1207
1628.51	402	390	393	393	1633.84	617	611	590	577	1639.24	1425	1287	1227	1218
1628.61	---	415	---	---	1633.94	620	600	604	----	1639.33	1474	1315	1301	1220
1628.71	406	409	409	412	1634.03	628	607	607	596	1639.43	1517	1353	1308	1240
1628.81	409	418	407	409	1634.13	643	637	600	608	1639.53	1518	1396	1319	1279
1628.91	402	393	393	384	1634.23	---	621	589	----	1639.63	1403	1350	1323	1295
1629.01	399	405	389	387	1634.33	643	614	603	594	1639.73	1417	1350	1295	1295
1629.11	427	415	424	407	1634.43	667	643	615	618	1639.82	1443	1350	1303	1303
1629.20	---	397	395	407	1634.53	655	----	634	617	1639.92	1435	1384	1308	1308
1629.30	420	410	394	400	1634.62	674	657	640	629	1640.02	1475	1393	1350	1350
1629.40	---	395	389	401	1634.72	681	659	667	643	1640.12	1479	1414	1352	1352
1629.50	403	413	413	407	1634.82	690	659	635	629	1640.22	1490	1490	1389	1389

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(g) s/R = 0.89; $\phi = 33.75^\circ$

Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$		
	0.1880 cm	0.3403 cm	0.5080 cm		0.1880 cm	0.3403 cm	0.5080 cm		0.1880 cm	0.3403 cm	0.5080 cm
1624.05	---	318	---	1629.70	428	412	376	1635.12	686	680	596
1624.15	---	---	---	1629.80	436	418	390	1635.21	659	659	586
1624.25	---	---	318	1629.90	446	422	403	1635.31	706	693	601
1624.34	333	343	---	1630.00	424	424	403	1635.41	720	697	613
1624.44	321	331	---	1630.09	456	433	401	1635.51	738	719	650
1624.54	327	329	---	1630.18	448	436	422	1635.61	747	731	653
1624.64	325	---	306	1630.29	427	427	396	1635.71	733	718	624
1624.74	324	343	311	1630.39	450	454	423	1635.80	770	741	653
1624.84	321	325	---	1630.49	426	424	---	1635.90	786	759	653
1624.94	336	328	---	1630.59	434	449	406	1636.00	756	745	669
1625.04	---	313	---	1630.69	484	474	433	1636.10	787	765	673
1625.24	330	334	321	1630.79	486	---	436	1636.20	797	776	694
1625.34	344	335	---	1630.88	446	457	432	1636.29	---	797	695
1625.44	339	311	333	1630.98	447	461	408	1636.39	817	789	684
1625.54	329	321	346	1631.08	478	484	452	1636.49	810	802	704
1625.64	---	---	334	1631.18	435	456	---	1636.59	870	846	722
1625.74	354	366	330	1631.28	467	443	420	1636.69	878	843	725
1625.83	346	359	340	1631.38	476	495	439	1636.79	879	845	735
1625.93	334	361	321	1631.48	472	476	505	1636.88	888	855	728
1626.13	344	341	329	1631.57	483	481	436	1636.98	880	847	734
1626.23	349	345	339	1631.67	479	479	445	1637.08	896	867	747
1626.33	355	338	355	1631.77	498	516	445	1637.28	942	905	753
1626.43	356	353	331	1631.87	489	484	459	1637.37	990	935	807
1626.53	343	351	323	1631.97	506	550	456	1637.57	1009	941	837
1626.63	340	344	321	1632.07	516	502	461	1637.67	1007	967	820
1626.73	364	351	---	1632.18	515	515	478	1637.77	1012	971	832
1626.83	365	349	343	1632.26	511	506	462	1637.86	1048	993	842
1626.93	365	---	356	1632.38	511	506	471	1637.96	1065	1013	856
1627.03	368	345	345	1632.46	521	507	454	1638.06	1130	1059	892
1627.22	373	379	367	1632.56	514	525	475	1638.16	1118	1081	880
1627.32	---	355	348	1632.76	533	530	484	1638.26	1128	1111	884
1627.42	366	372	344	1632.85	530	538	489	1638.35	1169	1105	931
1627.52	370	366	354	1632.95	545	538	494	1638.45	1164	1112	930
1627.62	384	355	378	1633.05	558	563	507	1638.55	1210	1164	948
1627.72	364	390	334	1633.15	563	559	509	1638.65	1190	1138	956
1627.82	377	367	355	1633.25	559	556	501	1638.75	1236	1177	984
1627.92	370	394	339	1633.35	544	560	495	1638.84	1186	1143	955
1628.02	383	388	371	1633.44	560	563	527	1638.94	1236	1169	----
1628.12	371	377	350	1633.54	577	571	510	1639.04	1285	1213	1011
1628.21	401	395	351	1633.64	569	578	500	1639.14	1287	1201	1034
1628.31	374	378	351	1633.74	599	591	545	1639.24	1327	1247	1022
1628.41	399	390	370	1633.84	608	598	538	1639.33	1326	1272	1052
1628.51	393	376	382	1633.94	604	598	536	1639.43	1335	1276	1050
1628.61	---	401	401	1634.03	604	594	533	1639.53	1376	1285	1068
1628.71	---	---	---	1634.13	608	600	541	1639.63	1390	1313	1090
1628.81	401	407	381	1634.23	608	610	561	1639.73	1393	1304	1075
1628.91	410	402	378	1634.33	611	605	553	1639.82	1448	1336	1102
1629.01	---	387	---	1634.43	629	624	552	1639.92	1407	1370	1117
1629.11	421	413	397	1634.53	647	---	551	1640.02	----	1384	1128
1629.20	389	419	371	1634.62	646	646	561	1640.12	1479	1391	1145
1629.30	406	402	373	1634.72	656	645	579	1640.22	1469	1383	1163
1629.40	395	395	389	1634.82	659	673	584	1640.31	1535	1413	1157
1629.50	407	397	395	1634.92	---	---	611	1640.41	1438		
1629.60	414	431	---	1635.02	671	666	587				

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(h) s/R = 0.89; $\phi = 146.25^\circ$

Time, sec	Temperature, °K, at x =			Time, sec	Temperature, °K, at x =			Time, sec	Temperature, °K, at x =		
	0.0305 cm	0.1824 cm	0.3399 cm		0.0305 cm	0.1824 cm	0.3399 cm		0.0305 cm	0.1824 cm	0.3399 cm
1624.15	---	315	303	1629.80	412	397	412	1635.21	665	659	631
1624.25	300	305	303	1629.90	436	434	414	1635.31	726	----	----
1624.34	300	300	300	1630.00	429	429	427	1635.41	712	684	674
1624.44	334	331	321	1630.09	433	433	433	1635.51	727	697	691
1624.54	311	311	324	1630.19	428	431	420	1635.61	741	710	702
1624.64	314	318	314	1630.29	416	405	407	1635.71	733	714	689
1624.74	324	324	333	1630.39	448	450	424	1635.80	755	722	722
1624.84	331	300	306	1630.49	441	429	429	1635.90	746	727	695
1624.94	340	321	318	1630.59	438	446	452	1636.00	783	766	719
1625.04	300	300	325	1630.69	477	----	474	1636.10	787	756	720
1625.24	318	349	340	1630.79	478	----	475	1636.20	808	792	761
1625.34	329	348	329	1630.88	471	463	435	1636.29	816	779	763
1625.44	309	330	327	1630.98	463	457	441	1636.39	831	793	759
1625.54	331	335	331	1631.08	460	457	469	1636.49	829	783	750
1625.64	325	348	338	1631.18	460	463	----	1636.59	843	808	792
1625.74	354	354	330	1631.28	469	455	457	1636.69	868	821	807
1625.83	353	356	340	1631.38	478	484	487	1636.79	892	828	808
1625.93	328	343	334	1631.48	----	478	455	1636.88	891	841	821
1626.13	319	349	338	1631.57	514	461	447	1636.98	907	837	823
1626.23	357	349	----	1631.67	492	490	474	1637.08	926	884	854
1626.33	350	346	331	1631.77	483	483	507	1637.28	953	897	874
1626.43	359	359	346	1631.87	500	503	484	1637.37	1018	959	906
1626.53	343	335	333	1631.97	492	494	489	1637.57	1057	981	938
1626.63	340	346	338	1632.07	522	502	499	1637.67	----	1005	941
1626.73	360	345	357	1632.16	524	515	501	1637.77	1046	988	942
1626.83	349	353	355	1632.26	486	492	478	1637.86	1118	1028	978
1626.93	---	371	338	1632.36	531	502	489	1637.96	1118	1041	995
1627.03	---	---	335	1632.46	509	500	518	1638.06	1181	1083	1025
1627.22	359	356	350	1632.56	527	516	516	1638.16	1160	1084	1047
1627.32	357	361	341	1632.76	533	513	527	1638.26	1193	1093	1052
1627.42	360	348	360	1632.85	551	532	527	1638.35	1256	1165	1081
1627.52	370	379	338	1632.95	557	538	532	1638.45	1237	1147	1089
1627.62	367	376	367	1633.05	560	528	531	1638.55	1284	1181	1114
1627.72	345	351	367	1633.15	567	542	559	1638.65	1288	1169	1112
1627.82	339	---	357	1633.25	567	553	534	1638.75	1309	1226	1181
1627.92	374	356	359	1633.35	566	550	541	1638.84	1271	----	1120
1628.02	383	371	385	1633.44	571	541	547	1638.94	1328	1226	1147
1628.12	377	383	359	1633.54	579	566	558	1639.04	1335	1232	1194
1628.21	370	389	383	1633.64	578	563	552	1639.14	1345	1260	1209
1628.31	372	372	366	1633.74	610	575	594	1639.24	1377	1287	1220
1628.41	393	387	410	1633.84	614	588	582	1639.33	1420	1284	1243
1628.51	382	387	382	1633.94	590	581	----	1639.43	1488	1319	1252
1628.61	419	---	415	1634.03	601	594	585	1639.53	1502	1369	1296
1628.71	412	403	---	1634.13	619	603	584	1639.63	1516	1384	1284
1628.81	389	409	395	1634.23	631	621	618	1639.73	1513	1407	1308
1628.91	405	405	---	1634.33	619	597	594	1639.82	1384	1313	1313
1629.01	395	---	---	1634.43	626	613	605	1639.92	1435	1350	1350
1629.11	424	424	407	1634.53	620	623	617	1640.02	1451	1380	1380
1629.20	389	409	377	1634.62	651	624	609	1640.12	1451	1395	1395
1629.30	402	396	402	1634.72	667	639	626	1640.22	1474	1418	1418
1629.40	410	---	413	1634.82	675	654	629	1640.31	1489	1489	1489
1629.50	401	393	413	1634.92	676	645	651	1640.41	1533	1533	1533
1629.60	420	422	412	1635.02	666	655	641	1640.51	1535	1535	1535
1629.70	414	408	408	1635.12	686	669	658	1640.61	1535	1535	1535

TABLE II. - TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(i) $s/R = 0.89$; $\phi = 258.75^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$		
	0.0363 cm	0.1897 cm	0.3414 cm	0.5080 cm		0.0363 cm	0.1897 cm	0.3414 cm	0.5080 cm		0.0363 cm	0.1897 cm	0.5080 cm
1624.05	329	329	---	336	1629.70	400	426	402	408	1635.02	696	666	644
1624.15	324	330	318	334	1629.80	425	412	400	412	1635.12	680	675	653
1624.25	305	305	300	315	1629.90	422	412	428	428	1635.21	702	675	654
1624.34	300	318	300	315	1630.00	412	418	427	429	1635.31	715	706	678
1624.44	321	321	325	334	1630.09	445	425	---	436	1635.41	705	702	674
1624.54	314	327	318	333	1630.19	440	434	436	428	1635.51	727	708	699
1624.64	300	---	321	329	1630.29	425	---	405	407	1635.61	774	734	702
1624.74	330	330	324	318	1630.39	462	---	450	445	1635.71	754	729	691
1624.84	315	---	306	309	1630.49	438	447	435	429	1635.80	763	---	717
1624.94	334	321	321	---	1630.59	452	452	438	426	1635.90	794	754	725
1625.04	315	309	300	313	1630.69	477	474	467	467	1636.00	777	761	750
1625.24	328	328	328	318	1630.79	481	467	478	478	1636.10	812	773	731
1625.34	---	348	318	---	1630.88	446	446	441	441	1636.20	808	797	748
1625.44	330	330	333	336	1630.98	453	457	445	445	1636.29	828	808	772
1625.54	325	319	331	331	1631.08	---	---	481	481	1636.39	848	820	787
1625.64	338	338	328	328	1631.18	442	449	449	449	1636.49	---	---	760
1625.74	336	339	343	330	1631.28	477	455	449	449	1636.59	---	838	808
1625.83	346	340	344	334	1631.38	487	487	470	470	1636.69	905	860	793
1625.93	349	343	330	321	1631.48	482	467	459	459	1636.79	906	850	820
1626.13	315	325	335	319	1631.57	459	456	442	442	1636.88	---	860	816
1626.23	357	339	357	345	1631.67	---	---	---	---	1636.98	907	880	825
1626.33	327	335	331	327	1631.77	---	---	---	---	1637.08	943	921	854
1626.43	346	353	346	340	1631.87	500	481	486	486	1637.28	979	---	874
1626.53	333	335	335	335	1631.97	514	497	494	494	1637.37	1019	930	918
1626.63	346	333	353	331	1632.07	514	508	487	487	1637.57	1059	980	935
1626.73	345	351	348	354	1632.16	530	524	507	507	1637.67	1084	1007	938
1626.83	359	346	340	349	1632.26	525	511	490	490	1637.77	1088	1026	971
1626.93	---	344	371	---	1632.36	---	497	491	491	1637.86	1122	1046	972
1627.03	329	355	323	359	1632.46	518	500	500	500	1637.96	1109	1063	966
1627.22	362	371	371	---	1632.56	519	525	497	497	1638.06	1134	1085	1021
1627.32	367	357	355	348	1632.76	541	539	524	524	1638.16	1170	1102	1012
1627.42	338	372	331	348	1632.85	530	530	522	522	1638.26	1179	1099	994
1627.52	360	338	376	354	1632.95	541	530	508	508	1638.35	1233	1151	1066
1627.62	351	376	370	---	1633.05	535	525	528	528	1638.45	1253	1138	1053
1627.72	357	349	---	351	1633.15	563	556	531	531	1638.55	1297	1158	1094
1627.82	331	341	335	367	1633.25	565	550	548	548	1638.65	1320	1181	1075
1627.92	367	372	364	356	1633.35	569	552	552	552	1638.75	1289	1202	1111
1628.02	377	371	365	344	1633.44	579	563	535	535	1638.84	1299	1209	1120
1628.12	374	356	356	383	1633.54	592	579	552	552	1638.94	1342	1252	1147
1628.21	367	379	---	---	1633.64	594	582	542	542	1639.04	1349	1265	1168
1628.31	390	387	372	357	1633.74	599	589	561	561	1639.14	1428	1305	1203
1628.41	381	381	384	387	1633.84	592	598	588	588	1639.24	1398	1313	1215
1628.51	399	381	376	382	1633.94	598	600	581	581	1639.33	1454	1362	1240
1628.61	405	415	---	---	1634.03	620	596	580	580	1639.43	1478	1365	1265
1628.71	403	394	403	400	1634.13	623	611	591	591	1639.53	1383	1259	
1628.81	412	409	407	389	1634.23	618	603	561	561	1639.63	1403	1291	
1628.91	393	396	381	374	1634.33	611	628	588	588	1639.73	1424	1334	
1629.01	393	393	395	368	1634.43	637	626	618	618	1639.82	1429	1309	
1629.11	418	418	409	---	1634.53	647	625	606	606	1639.92	1468	1345	
1629.20	403	401	407	395	1634.62	651	648	609	609	1640.02	1482	1370	
1629.30	388	388	390	388	1634.72	656	661	639	639	1640.12	1509	1365	
1629.40	395	395	395	365	1634.82	661	654	643	643	1640.22	1407		
1629.50	415	401	401	395	1634.92	699	694	634	634	1640.31	1410		
1629.60	434	418	426	422									

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(j) s/R = 1.00; $\phi = 28.00^\circ$

Time, sec	Temperature, °K, at x =				Time, sec	Temperature, °K, at x =				Time, sec	Temperature, °K, at x =			
	0.0328 cm	0.1834 cm	0.3350 cm	0.5080 cm		0.0328 cm	0.1834 cm	0.3350 cm	0.5080 cm		0.0328 cm	0.1834 cm	0.3350 cm	0.5080 cm
1624.05	310	---	303	---	1629.70	318	330	303	315	1635.12	357	---	---	364
1624.15	---	305	315	311	1629.80	300	306	325	315	1635.21	354	348	360	345
1624.25	---	300	300	300	1629.90	330	320	324	315	1635.31	367	355	346	365
1624.34	315	309	300	311	1630.00	330	324	318	330	1635.41	382	373	361	378
1624.44	321	319	321	315	1630.09	330	305	315	321	1635.51	376	385	376	---
1624.54	320	327	---	320	1630.19	311	309	321	321	1635.61	401	---	401	396
1624.64	314	310	325	325	1630.29	300	300	311	311	1635.71	364	---	364	370
1624.74	305	311	311	330	1630.39	331	328	328	325	1635.80	407	389	383	378
1624.84	300	300	309	300	1630.49	313	309	328	309	1635.90	409	397	389	395
1624.94	309	324	321	321	1630.59	320	327	345	324	1636.00	410	402	384	379
1625.04	300	---	300	300	1630.69	314	314	329	318	1636.10	397	377	389	367
1625.24	315	311	315	309	1630.79	344	---	---	---	1636.20	405	407	407	393
1625.34	320	305	324	320	1630.88	327	327	336	324	1636.29	---	387	372	374
1625.44	305	315	303	318	1630.98	335	331	331	318	1636.39	394	388	384	390
1625.54	309	306	300	300	1631.08	329	335	341	---	1636.49	395	374	395	387
1625.64	---	309	315	313	1631.18	300	---	---	---	1636.59	409	415	397	379
1625.74	315	321	305	327	1631.28	305	309	311	318	1636.69	397	400	397	388
1625.83	319	313	303	303	1631.38	338	333	345	349	1636.79	400	394	402	390
1625.93	---	300	311	309	1631.48	319	331	338	321	1636.88	396	---	---	402
1626.13	300	306	300	300	1631.57	327	---	314	309	1636.98	406	401	412	401
1626.23	324	315	311	311	1631.67	---	---	368	345	1637.08	416	377	416	405
1626.33	320	300	303	300	1631.77	309	---	345	331	1637.28	400	406	400	388
1626.43	303	319	309	300	1631.87	321	343	327	354	1637.37	409	409	406	403
1626.53	300	300	---	300	1631.97	341	---	359	350	1637.57	434	438	---	---
1626.63	303	309	303	300	1632.07	340	334	344	319	1637.67	427	409	406	406
1626.73	321	321	300	315	1632.16	353	---	365	340	1637.77	406	414	412	414
1626.83	315	305	303	309	1632.26	350	333	348	327	1637.86	419	401	407	393
1626.93	300	300	315	328	1632.36	324	311	328	321	1637.96	440	428	414	408
1627.03	306	300	300	300	1632.46	321	321	315	328	1638.06	455	434	440	---
1627.22	320	324	327	341	1632.56	345	354	345	339	1638.16	432	400	402	408
1627.32	306	300	306	300	1632.76	328	338	328	352	1638.26	442	442	431	392
1627.42	300	300	309	313	1632.85	354	339	345	354	1638.35	445	436	436	436
1627.52	306	303	315	308	1632.95	318	341	339	356	1638.45	455	457	455	441
1627.62	318	311	321	324	1633.05	339	319	364	---	1638.55	455	446	443	435
1627.72	300	300	309	311	1633.15	368	362	368	365	1638.65	---	416	408	---
1627.82	300	300	300	300	1633.25	339	339	364	327	1638.75	454	439	442	445
1627.92	323	300	308	305	1633.35	353	330	343	336	1638.84	436	506	428	439
1628.02	309	309	324	324	1633.44	345	354	345	348	1638.94	441	429	412	429
1628.12	306	319	300	300	1633.54	345	354	351	351	1639.04	---	432	453	441
1628.21	300	306	319	331	1633.64	---	---	328	328	1639.14	439	439	445	435
1628.31	311	309	311	303	1633.74	336	345	374	357	1639.24	450	464	438	447
1628.41	315	318	321	324	1633.84	367	370	370	---	1639.33	463	469	469	457
1628.51	315	321	328	318	1633.94	346	355	349	343	1639.43	486	469	463	457
1628.61	---	---	300	325	1634.03	360	351	351	348	1639.53	475	463	447	453
1628.71	334	---	315	---	1634.13	353	338	340	346	1639.63	499	474	479	466
1628.81	327	305	303	320	1634.23	361	---	346	331	1639.73	487	479	474	487
1628.91	306	300	309	306	1634.33	---	341	361	364	1639.82	477	474	491	454
1629.01	331	306	300	325	1634.43	364	351	364	355	1639.92	495	484	484	484
1629.11	330	320	336	327	1634.53	345	366	349	---	1640.02	510	491		
1629.20	315	300	305	---	1634.62	356	352	338	356	1640.12	503	498		
1629.30	315	305	300	---	1634.72	353	365	355	349	1640.22	501			
1629.40	321	300	300	---	1634.82	350	356	362	350	1640.31	486			
1629.50	303	300	300	---	1634.92	---	372	374	381	1640.41	494			
1629.60	335	---	---	324	1635.02	370	370	349	357	1640.51	481			

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Continued

(k) $s/R = 1.00$; $\phi = 152.00^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$			
	0.0300 cm	0.1801 cm	0.3332 cm	0.5080 cm		0.0300 cm	0.1801 cm	0.3332 cm	0.5080 cm		0.0300 cm	0.1801 cm	0.3332 cm	0.5080 cm
1624.05	---		306		1629.70	311	309	309	324	1635.12	349	340	353	357
1624.15	---	309			1629.80	313	306	300	313	1635.21	354	339	339	343
1624.25	300	300	300	303	1629.90	318	330	330	309	1635.31	340	---	382	387
1624.34	300	300	300	300	1630.00	315	321	311	311	1635.41	359	373	370	376
1624.44	309	---	300	---	1630.09	334	343	321	318	1635.51	376	367	343	388
1624.54	300	300	302	305	1630.19	315	321	300	315	1625.61	---	393	405	393
1624.64	300	300	302	306	1630.29	318	300	300	300	1635.71	354	360	364	354
1624.74	311	311	309	303	1630.39	328	315	321	321	1635.80	374	360	381	383
1624.84	300	300	300	300	1630.49	323	306	306	300	1635.90	374	377	379	379
1624.94	300	309	305	300	1630.59	327	300	324	320	1636.00	376	393	382	373
1625.04	300	300	300	300	1630.69	318	314	325	318	1636.10	379	361	395	373
1625.24	300	315	309	315	1630.79	---	---	300	---	1636.20	---	399	395	384
1625.34	311	311	309	300	1630.88	327	324	324	303	1636.29	374	381	362	372
1625.44	300	300	300	305	1630.98	314	323	314	320	1636.39	384	390	384	382
1625.54	300	315	306	309	1631.08	344	319	319	329	1636.49	381	405	372	381
1625.64	306	315	321	300	1631.18	300	300	300	300	1636.59	391	388	385	379
1625.74	305	305	327	318	1631.28	305	300	300	305	1636.69	403	406	391	397
1625.83	306	319	319	300	1631.38	336	336	324	311	1636.79	396	396	382	---
1625.93	303	305	300	305	1631.48	---	325	313	315	1636.88	406	378	400	384
1626.13	300	300	300	300	1631.57	329	318	309	314	1636.98	406	374	377	395
1626.23	315	311	309	300	1631.67	---	---	340	---	1637.08	396	390	393	387
1626.33	300	305	300	311	1631.77	335	315	313	335	1637.28	402	394	396	378
1626.43	321	319	321	315	1631.87	336	333	315	343	1637.37	394	400	419	406
1626.53	300	300	300	300	1631.97	341	341	333	348	1637.57	424	408	418	402
1626.63	300	300	306	303	1632.07	338	319	334	328	1637.67	415	418	409	415
1626.73	300	303	300	300	1632.16	---	344	340	334	1637.77	420	420	418	400
1626.83	309	315	305	328	1632.26	327	327	320	327	1637.86	410	428	405	389
1626.93	315	315	321	315	1632.36	324	321	303	345	1637.96	420	406	402	414
1627.03	300	308	300	300	1632.46	---	315	321	325	1638.06	443	414	412	408
1627.22	320	324	300	---	1632.56	339	330	324	324	1638.16	414	412	414	414
1627.32	303	300	300	---	1632.76	338	334	334	315	1638.26	422	422	438	427
1627.42	300	300	300	300	1632.85	330	338	336	339	1638.35	456	445	433	431
1627.52	300	325	300	306	1632.95	362	324	324	329	1638.45	447	435	441	452
1627.62	309	305	315	309	1633.05	357	341	313	319	1638.55	426	421	418	432
1627.72	305	309	300	300	1633.15	365	345	348	362	1638.65	425	405	413	405
1627.82	300	309	300	300	1633.25	351	339	333	330	1638.75	439	442	425	431
1627.92	305	300	311	305	1633.35	346	334	334	330	1638.84	447	439	436	439
1628.02	305	300	318	305	1633.44	327	354	345	336	1638.94	429	418	426	420
1628.12	300	315	309	303	1633.54	354	345	348	339	1639.04	438	429	441	424
1628.21	309	313	300	319	1633.64	336	334	345	324	1639.14	449	441	453	433
1628.31	300	309	305	309	1633.74	348	364	360	364	1639.24	439	433	436	441
1628.41	305	309	311	321	1633.84	344	372	367	353	1639.33	447	443	449	449
1628.51	318	305	321	315	1633.94	336	328	328	353	1639.43	457	455	455	449
1628.61	325	329	318	325	1634.03	360	348	336	339	1639.53	447	455	449	
1628.71	321	328	324	311	1634.13	346	346	356	346	1639.63	457	452	469	
1628.81	324	333	324	341	1634.23	---	353	378	378	1639.73	460	468	456	
1628.91	300	306	309	309	1634.33	341	335	351	351	1639.82	460	445	445	
1629.01	315	319	303	313	1634.43	343	324	351	343	1639.92	493	478	462	
1629.11	---	327	315	330	1634.53	349	372	349	345	1640.02	514	489	474	
1629.20	300	300	300	303	1634.62	353	340	356	344	1640.12	500	492	489	
1629.30	311	300	300	303	1634.72	371	361	355	371	1640.22	503	490		
1629.40	309	303	303	303	1634.82	373	368	371	366	1640.31	500	486		
1629.50	315	305	308	300	1634.92	350	388	366	366	1640.41	506	491		
1629.60	305	329	303	329	1635.02	349	349	351	364					

TABLE II.- TEMPERATURES RECORDED IN FIRST BERYLLIUM CALORIMETER LAYER - Concluded

(i) s/R = 1.00; $\phi = 242.00^{\circ}$

Time, sec	Temperature, °K, at x =			Time, sec	Temperature, °K, at x =			Time, sec	Temperature, °K, at x =		
	0.0295 cm	0.1783 cm	0.5080 cm		0.0295 cm	0.1783 cm	0.5080 cm		0.0295 cm	0.1783 cm	0.5080 cm
1624.05	314	325	300	1629.40	309	303	300	1634.53	343	351	351
1624.15	300	328	305	1629.50	305	327	315	1634.62	346	334	346
1624.25	300	300	300	1629.60	329	314	335	1634.72	---	355	340
1624.34	300	300	300	1629.70	324	300	328	1634.82	368	359	344
1624.44	303	313	300	1629.80	313	300	313	1634.92	362	---	354
1624.54	309	309	300	1629.90	318	324	318	1635.02	361	351	357
1624.64	303	300	300	1630.00	330	309	318	1635.12	361	349	340
1624.74	300	300	311	1630.09	324	305	300	1635.21	354	343	333
1624.84	300	306	300	1630.19	309	311	321	1635.31	361	370	359
1624.94	303	305	321	1630.29	305	300	305	1635.41	370	359	355
1625.04	300	300	300	1630.39	325	334	331	1635.51	373	370	361
1625.24	311	315	318	1630.49	306	300	300	1635.61	384	393	---
1625.34	---	---	---	1630.59	320	318	324	1635.71	360	374	354
1625.44	311	300	300	1630.69	318	314	310	1635.80	374	387	381
1625.54	300	300	300	1630.79	---	---	---	1635.90	389	379	391
1625.64	319	303	306	1630.88	327	311	318	1636.00	399	361	373
1625.74	300	311	309	1630.98	303	314	323	1636.10	367	353	377
1625.83	303	313	306	1631.08	331	319	---	1636.20	413	401	393
1625.93	305	300	300	1631.18	300	300	300	1636.29	372	372	374
1626.13	300	303	---	1631.28	334	311	305	1636.39	384	366	372
1626.23	311	300	---	1631.38	321	324	327	1636.49	364	372	---
1626.33	300	300	303	1631.48	334	315	300	1636.59	376	391	379
1626.43	300	300	300	1631.57	311	311	305	1636.69	394	394	388
1626.53	300	300	300	1631.67	316	---	---	1636.79	390	396	388
1626.63	306	300	300	1631.77	309	300	---	1636.88	373	406	548
1626.73	300	300	309	1631.87	309	327	318	1636.98	434	397	397
1626.83	300	321	309	1631.97	324	344	335	1637.08	445	387	387
1626.93	313	303	300	1632.07	325	313	328	1637.28	475	378	378
1627.03	300	300	300	1632.16	340	331	338	1637.37	505	382	382
1627.22	329	314	314	1632.26	329	335	339	1637.57	525	402	402
1627.32	300	306	303	1632.36	309	303	---	1637.67	532	403	403
1627.42	319	300	300	1632.46	315	321	313	1637.77	549	414	414
1627.52	300	300	321	1632.56	330	---	341	1637.86	549	407	407
1627.62	328	300	300	1632.76	331	334	---	1637.96	570	408	408
1627.72	300	305	300	1632.85	336	333	336	1638.06	603	432	432
1627.82	319	300	300	1632.95	348	350	335	1638.16	577	400	400
1627.92	328	300	303	1633.05	341	331	329	1638.26	413	413	413
1628.02	300	303	300	1633.15	356	354	350	1638.35	415	415	415
1628.12	309	300	313	1633.25	327	336	336	1638.45	438	438	438
1628.21	306	329	300	1633.35	---	324	324	1638.55	426	426	426
1628.31	305	300	303	1633.44	330	348	341	1638.65	405	405	405
1628.41	321	318	315	1633.54	357	341	318	1638.75	436	436	436
1628.51	300	300	309	1633.64	328	336	334	1638.84	436	436	436
1628.61	306	336	300	1633.74	357	339	339	1638.94	---	---	---
1628.71	318	324	315	1633.84	355	367	353	1639.04	438	438	438
1628.81	315	305	300	1633.94	---	---	330	1639.14	449	449	449
1628.91	313	315	303	1634.03	345	339	345	1639.24	459	459	459
1629.01	303	309	303	1634.13	340	353	353	1639.33	453	453	453
1629.11	324	320	327	1634.23	359	344	335	1639.43	443	443	443
1629.20	321	303	303	1634.33	---	323	315	1639.53	455	455	455
1629.30	---	300	318	1634.43	349	351	349				

TABLE III.- TEMPERATURES RECORDED IN SECOND BERYLLIUM CALORIMETER LAYER

(a) $s/R = 0.10$; $\phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$	
	0.0356 cm	0.1880 cm	0.3404 cm	0.5080 cm		0.0356 cm	0.5080 cm
1642.61	397	318	---	---	1644.02	1141	843
1642.66	453	372	336	336	1644.12	1155	850
1642.71	484	407	366	372	1644.21	1163	885
1642.76	486	419	374	346	1644.31	1255	941
1642.81	534	457	393	383	1644.36	1235	927
1642.85	566	463	434	413	1644.41	1261	957
1642.90	579	492	452	413	1644.46	1303	978
1642.95	606	516	467	457	1644.50	1350	990
1643.00	623	516	455	457	1644.55	1322	993
1643.05	650	544	484	461	1644.60	1403	---
1643.10	680	585	514	506	1644.65	1424	1028
1643.15	711	613	530	513	1644.75	1462	1078
1643.20	734	626	549	535	1644.79	----	1103
1643.24	746	643	573	562	1644.84	----	1100
1643.29	779	667	604	---	1644.89	----	1138
1643.34	811	686	606	580	1644.94	----	1136
1643.39	814	---	623	586	1644.99	----	1170
1643.44	837	---	---	601	1645.04	----	1164
1643.53	881	---	---	661			
1643.58	935	---	---	669			
1643.63	924	---	---	680			
1643.68	978	---	---	658			
1643.73	980	---	---	730			
1643.83	1031	---	---	769			

TABLE III.- TEMPERATURES RECORDED IN SECOND BERYLLIUM CALORIMETER LAYER - Continued

(b) $s/R = 0.54; \phi = 33.75^\circ$ (c) $s/R = 0.54; \phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$			
	0.0300 cm	0.1829 cm	0.3353 cm	0.5080 cm		0.0300 cm	0.1829 cm	0.3353 cm	0.5080 cm
1642.51	300	---	---	---	1644.31	---	1035	921	---
1642.56	308	302	---	---	1644.36	1168	1030	923	873
1642.61	385	309	300	300	1644.41	1210	1075	973	905
1642.66	467	393	357	351	1644.46	---	1058	965	929
1642.71	498	427	387	357	1644.50	1219	1107	1007	927
1642.76	498	422	374	353	1644.60	1273	1119	1034	973
1642.81	503	446	399	401	1644.70	1338	1152	1082	1004
1642.85	540	469	416	399	1644.79	1354	1176	1071	---
1642.90	557	486	431	419	1644.89	1406	1237	1106	1058
1642.95	606	516	472	443	1644.94	1399	1229	1114	---
1643.00	619	527	472	461	1644.99	1451	1272	1155	---
1643.05	645	556	494	475	1645.08	1502	1288	1166	1102
1643.10	680	577	533	503	1645.13	1483	1315	1175	1096
1643.15	681	590	530	509	1645.18	---	1311	1176	1113
1643.20	693	599	547	509	1645.23	1528	1315	1186	1129
1643.24	730	620	570	528	1645.37	---	1336	1228	1173
1643.29	755	634	592	557	1645.42	---	1364	1260	---
1643.34	780	667	591	553	1645.47	---	1357	1260	1197
1643.39	792	678	608	---	1645.52	---	1393	1260	1206
1643.44	817	689	626	588	1645.57	---	1404	1288	1199
1643.53	865	747	680	643	1645.62	---	1411	1292	1218
1643.63	904	767	697	644	1645.66	---	1442	1304	1245
1643.68	---	---	700	653	1645.71	---	1435	1339	1248
1643.73	942	798	736	708	1645.76	---	---	1339	1252
1643.83	967	837	780	728	1645.81	---	1460	1359	1289
1643.88	---	---	---	728	1645.86	---	---	1354	1289
1644.02	---	911	830	776	1645.91	---	---	1305	1297
1644.07	1050	---	---	780	1645.95	---	---	1373	1297
1644.12	1072	935	842	805	---	---	---	1645.18	---
1644.17	1096	---	---	964	870	838	---	1645.37	---

TABLE III.- TEMPERATURES RECORDED IN SECOND BERYLLIUM CALORIMETER LAYER - Continued

(d) $s/R = 0.90; \phi = 33.75^\circ$

Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$ 0.3355 cm
1642.46	303
1642.56	383
1642.66	476
1642.76	486
1642.85	532
1642.95	577
1643.05	618
1643.15	657
1643.24	686
1643.34	705
1643.44	716
1643.53	785
1643.63	832
1643.73	846
1644.02	911
1644.12	944
1644.21	964
1644.31	1030
1644.41	1069
1644.50	1081
1644.60	1119
1644.70	1155
1644.79	1196
1644.89	1220
1644.99	1231
1645.08	1308
1645.18	1335
1645.28	1354
1645.37	1400
1645.47	1471

(e) $s/R = 0.90; \phi = 146.25^\circ$

Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$ 0.0284 cm 0.1842 cm 0.3330 cm			Temperature, $^{\circ}\text{K}$, at $x =$ 0.5080 cm			Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$ 0.0284 cm 0.1842 cm 0.3330 cm			Temperature, $^{\circ}\text{K}$, at $x =$ 0.5080 cm								
	0.0284 cm	0.1842 cm	0.3330 cm	0.5080 cm	0.0284 cm	0.1842 cm	0.3330 cm	0.5080 cm											
1642.61	373	324	---	---	1644.12	1093	938	845	797	1642.66	450	387	348	336	1644.21	1102	972	870	827
1642.71	467	425	374	364	1644.31	1155	---	---	---	1642.76	492	416	362	338	1644.41	1228	1047	994	908
1642.81	511	442	395	371	1644.50	1241	1087	1011	935	1642.85	545	469	405	393	1644.60	1289	1123	1037	953
1642.90	549	481	442	407	1644.70	---	1170	---	1004	1642.95	594	486	461	447	1644.75	1349	---	1070	---
1643.00	611	525	461	453	1644.79	1364	1185	1083	1018	1643.05	624	536	486	464	1644.89	1419	1229	1124	1068
1643.15	657	584	486	461	1644.79	1364	1185	1083	1018	1643.10	656	552	492	469	1644.99	---	1260	1168	1100
1643.24	686	643	525	461	1644.79	1364	1185	1083	1018	1643.15	668	579	535	498	1645.04	1454	---	---	---
1643.34	705	643	536	486	1644.79	1364	1185	1083	1018	1643.20	709	601	538	515	1645.08	1497	1335	1209	1129
1643.44	716	643	552	492	1644.99	---	---	---	---	1643.24	714	611	570	532	1645.13	1495	---	---	---
1643.53	785	668	579	535	1645.18	1492	1351	1245	1159	1643.29	730	643	579	543	1645.23	1533	---	---	---
1643.63	832	709	601	538	1645.23	1533	---	---	---	1643.34	760	645	---	559	1645.23	1533	---	---	---
1643.73	846	714	611	570	1645.23	1533	---	---	---	1643.39	794	661	600	---	1645.23	1533	---	---	---
1644.02	911	730	643	579	1645.23	1533	---	---	---	1643.44	798	---	635	599	1645.23	1533	---	---	---
1644.12	944	760	645	579	1645.23	1533	---	---	---	1643.49	---	710	648	---	1645.23	1533	---	---	---
1644.21	964	794	661	600	1645.23	1533	---	---	---	1644.31	1030	1069	1643.49	---	1645.23	1533	---	---	---
1644.31	1030	1069	1643.49	---	1645.23	1533	---	---	---	1644.41	1069	1081	1643.53	848	1644.50	1081	1308	1335	1354
1644.50	1081	1081	1643.53	848	1644.50	1081	1308	1335	1354	1644.60	1119	1643.63	875	773	1644.60	1119	1335	1354	1371
1644.70	1155	1155	1643.73	916	1644.70	1155	1335	1354	1371	1644.79	1196	1643.83	979	856	1644.79	1196	1335	1354	1371
1644.79	1196	1196	1643.83	979	1644.79	1196	1335	1354	1371	1644.89	1220	1644.02	1044	905	1644.89	1220	1335	1354	1371
1644.99	1231	1231	1644.41	1069	1645.08	1308	1335	1354	1371	1645.18	1335	1645.28	1400	1400	1645.37	1471	1471	1471	1471

(e) $s/R = 0.90; \phi = 146.25^\circ$

TABLE III.- TEMPERATURES RECORDED IN SECOND BERYLLIUM CALORIMETER LAYER - Concluded

Time, sec	Temperature, °K, at x = 0.0310 cm	0.3358 cm	0.5080 cm
1642.66	---	336	---
1642.76	300	306	306
1642.85	306	313	319
1642.95	341	---	---
1643.05	351	351	---
1643.15	355	330	1643.15
1643.24	349	353	1643.24
1643.34	359	346	1643.34
1643.44	---	330	1643.44
1643.53	372	351	354
1643.63	366	353	362
1643.73	379	376	367
1643.83	385	367	388
1644.02	395	372	410
1644.12	373	373	382
1644.21	401	395	403
1644.31	396	376	396
1644.50	400	---	385
1644.60	428	410	414
1644.70	435	408	414
1644.79	414	426	416
1644.89	420	408	424
1644.99	456	447	436
1645.08	428	413	422
1645.18	---	435	447
1645.28	468	434	---
1645.37	434	434	460
1645.47	477	460	481
1645.57	478	450	495
1645.66	497	505	535
1645.76	500	500	511
1645.86	533	535	558
1645.95	530	532	---

Time, sec	Temperature, °K, at x = 0.0318 cm	0.1875 cm	0.3399 cm	0.5080 cm
1642.66	1642.66	324	---	327
1642.76	1642.76	---	315	303
1642.85	1642.85	325	334	306
1642.95	1642.95	345	339	319
1643.05	1643.05	343	348	364
1643.15	1643.15	359	376	330
1643.24	1643.24	353	373	349
1643.34	1643.34	349	340	349
1643.44	1643.44	367	346	340
1643.53	1643.53	361	366	370
1643.63	1643.63	354	393	374
1643.73	1643.73	372	399	372
1643.83	1643.83	397	391	381
1644.02	1644.02	415	419	407
1644.12	1644.12	397	418	400
1644.21	1644.21	422	428	421
1644.31	1644.31	436	426	431
1644.50	1644.50	443	449	443
1644.60	1644.60	429	432	415
1644.70	1644.70	428	452	428
1644.79	1644.79	449	453	432
1644.89	1644.89	467	462	450
1644.99	1644.99	467	469	435
1645.08	1645.08	1644.99	478	482
1645.18	1645.18	447	1645.08	472
1645.28	1645.28	434	1645.18	472
1645.37	1645.37	434	1645.28	482
1645.47	1645.47	477	1645.37	487
1645.57	1645.57	435	1645.47	472
1645.66	1645.66	468	1645.57	472
1645.76	1645.76	500	1645.66	475
1645.86	1645.86	533	1645.76	460
1645.95	1645.95	530	1645.86	498

Time, sec	Temperature, °K, at x = 0.0292 cm	0.1819 cm	0.3312 cm	0.5080 cm
1642.66	1642.66	---	---	---
1642.76	1642.76	306	303	303
1642.85	1642.85	319	306	321
1642.95	1642.95	345	339	311
1643.05	1643.05	343	336	330
1643.15	1643.15	359	330	349
1643.24	1643.24	353	340	334
1643.34	1643.34	349	353	336
1643.44	1643.44	367	346	324
1643.53	1643.53	361	366	370
1643.63	1643.63	354	393	372
1643.73	1643.73	372	399	353
1643.83	1643.83	397	391	353
1644.02	1644.02	415	413	384
1644.12	1644.12	397	418	361
1644.21	1644.21	422	428	370
1644.31	1644.31	436	426	384
1644.50	1644.50	443	449	376
1644.60	1644.60	429	432	406
1644.70	1644.70	428	452	385
1644.79	1644.79	449	453	367
1644.89	1644.89	467	462	379
1644.99	1644.99	467	469	359
1645.08	1645.08	413	422	379
1645.18	1645.18	447	440	402
1645.28	1645.28	434	432	402
1645.37	1645.37	434	432	402
1645.47	1645.47	477	482	402
1645.57	1645.57	435	447	393
1645.66	1645.66	468	443	428
1645.76	1645.76	505	445	429
1645.86	1645.86	533	445	429
1645.95	1645.95	530	446	429

TABLE IV.- TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER

(a) $s/R = 0.10;$ $\phi = 28.00^\circ$

Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	
	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm
1648.07	300	1652.12	1154	1648.07	300	300	300	1650.57
1648.17	407	1652.41	1179	1648.17	351	351	325	1650.62
1648.26	415	1652.51	1159	1648.26	384	334	315	1650.67
1648.36	476	1652.60	1208	1648.31	309	336	300	1650.72
1648.46	495	1652.70	1235	1648.36	454	402	355	1650.77
1648.55	523	1652.80	1210	1648.41	410	376	355	1650.82
1648.75	542	1652.90	1196	1648.46	479	441	390	1650.86
1648.94	613	1653.00	1232	1648.51	509	432	388	1650.91
1649.03	680	1653.09	1253	1648.55	514	486	419	1650.96
1649.13	678	1653.19	1240	1648.60	519	454	415	1651.01
1649.23	699	1653.38	1248	1648.65	559	484	436	1651.06
1649.32	704	1653.48	1240	1648.75	587	492	447	1651.11
1649.42	740	1653.57	1251	1648.80	542	490	433	1651.15
1649.51	744	1653.67	1224	1648.94	635	565	518	1651.20
1649.71	798	1653.77	1247	1648.99	613	551	499	1651.25
1649.80	821	1653.87	1247	1649.03	680	589	517	1651.30
1649.90	845	1653.96	1269	1649.08	648	568	513	1651.35
1650.09	880	1654.06	1257	1649.13	676	611	580	1651.40
1650.19	919	1654.16	1256	1649.18	667	600	543	1651.44
1650.28	935	1654.25	1272	1649.23	697	644	573	1651.49
1650.38	965	1654.35	1285	1649.28	673	627	557	1651.54
1650.48	983	1654.55	1296	1649.32	717	656	590	1651.59
1650.57	979	1654.64	1289	1649.37	719	643	598	1651.64
1650.67	992	1654.74	1284	1649.42	733	685	605	1651.69
1650.77	1009	1654.84	1291	1649.47	738	674	605	1651.73
1650.86	1045	1654.94	1291	1649.51	758	689	625	1651.78
1650.96	1050	1655.03	1307	1649.56	741	670	598	1651.93
1651.06	1077	1655.13	1289	1649.61	797	722	638	1651.98
1651.15	1080	1655.23	1284	1649.66	---	---	641	1652.02
1651.25	1058	1655.33	1308	1649.71	788	714	648	1652.07
1651.35	1068	1655.42	1280	1649.76	793	721	659	1652.12
1651.44	1091	1655.52	1283	1649.80	807	745	666	1652.17
1651.54	1099	1655.62	1280	1649.85	807	741	685	1652.44
1651.64	1134	1655.72	1275	1649.90	813	757	715	1652.46
1651.73	1118	1655.81	1301	1649.95	837	763	715	1652.51
1651.93	1148	1655.91	1288	1650.00	841	776	707	1652.56
1652.02	1158			1650.09	875	805	768	1652.60
				1650.14	842	856	779	1652.65
				1650.19	864	808	772	1652.70
				1650.24	902	839	779	1652.75
				1650.29	872	---	---	1652.80
				1650.34	913	875	796	1652.90
				1650.38	949	885	817	1652.95
				1650.43	957	878	815	1653.00
				1650.48	937	883	821	1653.05
				1650.53	949	911	837	1653.09

(b) $s/R = 0.10;$ $\phi = 146.25^\circ$

Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm		Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	
	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm	Time, sec	Temperature, $^\circ\text{K}$, at $x =$ 0.0318 cm
1650.57	900	900	923	906	940	840	928	857
1650.62	977	977	914	934	934	871	928	866
1650.67	992	992	939	939	939	884	928	879
1650.72	998	998	920	920	920	884	928	879
1650.77	980	980	928	928	928	884	928	879
1651.01	1018	1018	962	962	962	880	928	879
1651.06	1054	1054	979	979	979	920	928	879
1651.11	1039	1039	971	971	971	920	928	879
1651.15	1038	1038	985	985	985	907	928	879
1651.20	1057	1057	999	999	999	915	928	879
1651.25	1066	1066	978	978	978	942	928	879
1651.30	1047	1047	999	999	999	934	928	879
1651.35	1059	1059	1007	1007	1007	953	928	879
1651.40	1053	1053	1027	1027	1027	945	928	879
1651.44	1083	1083	1011	1011	1011	957	928	879
1651.49	1079	1079	1031	1031	1031	963	928	879
1651.54	1113	1113	1034	1034	1034	992	928	879
1651.59	1099	1099	1044	1044	1044	984	928	879
1651.64	1101	1101	1015	1015	1015	1000	928	879
1651.69	1119	1119	1059	1059	1059	1000	928	879
1651.73	1116	1116	1062	1062	1062	1005	928	879
1651.78	1103	1103	1066	1066	1066	993	928	879
1651.93	1138	1138	1097	1097	1097	1053	928	879
1651.98	1142	1142	1089	1089	1089	1039	928	879
1652.02	1131	1131	1030	1030	1030	1000	928	879
1652.07	1140	1140	1089	1089	1089	1025	928	879
1652.12	---	---	1107	1107	1107	1052	928	879
1652.17	1148	1148	1128	1128	1128	1040	928	879
1652.44	---	---	1103	1103	1103	1079	928	879
1652.46	---	---	1113	1113	1113	1079	928	879
1652.51	---	---	1134	1134	1134	1087	928	879
1652.56	---	---	1123	1123	1123	1093	928	879
1652.60	---	---	1101	1101	1101	1101	928	879
1652.65	---	---	1111	1111	1111	1111	928	879
1652.70	---	---	1130	1130	1130	1130	928	879
1652.75	---	---	1123	1123	1123	1123	928	879
1652.80	---	---	1130	1130	1130	1130	928	879
1652.90	---	---	1145	1145	1145	1145	928	879
1652.95	---	---	1165	1165	1165	1165	928	879

TABLE IV - TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Continued

(c) $s/R = 0.10$; $\phi = 242.00^\circ$ (d) $s/R = 0.57$; $\phi = 28.00^\circ$

Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$				Time, sec	Temperature, °K, at $x =$			
	0.0302 cm	0.1867 cm	0.3325 cm	0.5080 cm		0.0302 cm	0.1867 cm	0.3325 cm	0.5080 cm		0.1814 cm	0.3366 cm	0.5080 cm	0.1814 cm
1648.07	324	300	300	300	1652.80	1217	1173	1152	1126	1648.07	300	300	300	---
1648.26	552	432	359	370	1652.90	1202	1169	1142	1130	1648.26	334	311	300	1076
1648.36	530	466	431	396	1653.00	1248	1186	1188	1174	1648.36	387	360	333	1087
1648.46	568	493	457	468	1653.09	---	1207	1159	1171	1648.46	435	409	359	1087
1648.56	562	495	473	438	1653.19	1256	1199	1174	1174	1648.55	446	421	405	1079
1648.65	603	545	509	498	1653.38	1248	1209	1182	1159	1648.75	467	441	419	1099
1648.75	610	550	503	490	1653.48	1256	1212	1199	1181	1648.94	510	497	471	1126
1648.94	643	584	534	524	1653.57	1248	1209	1177	1174	1649.03	585	534	525	1132
1649.03	681	618	581	554	1653.67	1229	1233	1186	1171	1649.13	568	543	518	1129
1649.13	699	629	584	551	1653.77	1247	1214	1208	1185	1649.23	600	562	538	1136
1649.23	718	644	606	584	1653.87	1267	1237	1224	1186	1649.32	633	590	556	1145
1649.32	751	688	619	619	1653.96	1304	1259	1212	1199	1649.42	664	620	597	1147
1649.42	769	708	660	645	1654.06	1253	1244	1221	1209	1649.51	657	611	590	1146
1649.51	776	708	663	634	1654.16	1301	1240	1249	1240	1649.71	699	661	650	1169
1649.61	812	730	685	666	1654.25	1277	1252	1192	1649.80	728	675	664	1174	
1649.71	814	751	714	680	1654.35	1301	1235	1225	1225	1649.90	757	710	689	1193
1649.80	840	779	728	701	1654.55	1277	1268	1248	1241	1650.09	795	737	718	1180
1649.90	883	800	724	744	1654.64	1269	1269	1264	1241	1650.19	823	776	768	1188
1650.00	---	---	753	731	1654.74	1284	1271	---	1245	1650.29	839	802	764	1186
1650.19	938	878	823	808	1654.84	1277	1268	1275	1251	1650.38	872	821	807	1209
1650.29	949	891	839	829	1654.94	1261	---	1229	1252	1650.48	860	815	804	1207
1650.38	977	919	866	853	1655.03	1284	1271	1255	1255	1650.57	895	857	821	1241
1650.48	969	907	886	831	1655.13	1289	1269	1260	1267	1650.67	922	866	843	1186
1650.57	997	929	871	837	1655.23	1300	1273	1264	1253	1650.77	900	867	878	1217
1650.67	1030	955	903	885	1655.33	1296	1285	1279	1253	1650.86	920	892	859	1210
1650.77	1020	939	928	887	1655.42	1283	1272	---	1263	1650.96	944	905	883	1223
1650.86	1034	985	945	898	1655.52	1267	1280	1287	1253	1651.06	969	918	890	1241
1650.96	1041	990	924	924	1655.62	1279	1285	---	1252	1651.15	963	915	878	1221
1651.06	1069	1005	965	963	1655.72	1288	1284	1288	1255	1651.25	966	920	928	1227
1651.15	1054	1007	973	959	1655.81	1299	---	---	1278	1651.35	973	920	973	1245
1651.25	1093	1031	974	960	1655.91	1285	---	---	1265	1651.44	985	929	966	1237
1651.35	1082	1033	981	959	1656.01	1289	---	---	1253	1651.54	1012	975	966	1241
1651.44	1097	1037	999	988	1656.11	1034	---	---	1253	1651.64	1035	992	971	1268
1651.54	1130	1081	1044	992	1656.20	1066	1066	1066	1066	1651.73	1041	997	973	1240
1651.64	1137	1085	1039	1006	1656.30	---	---	---	1223	1651.93	---	1005	999	1263
1651.73	1124	1066	1033	1007	1656.40	---	---	---	1285	1652.02	1060	1030	1002	1247
1651.93	1151	1112	1069	1045	1656.50	---	---	---	1296	1652.12	1064	1022	997	1265
1652.02	1137	1100	1064	1044	1656.59	---	---	---	1301	1652.41	1100	1085	1075	1266
1652.12	1164	1111	1072	1052	1656.69	---	---	---	1275	1652.51	1248	1248	1247	1240
1652.41	---	1158	1120	1094	1656.79	---	---	---	1285	1652.60	1260	1260	1260	1241
1652.51	1182	1132	1101	1089	1656.89	---	---	---	1296	1652.61	1271	1271	1271	1247
1652.60	1202	1169	1137	1111	1657.08	---	---	---	1301	1652.70	1283	1283	1283	1247
1652.70	1207	1177	1154	1113	---	---	---	---	1275	1652.79	1288	1288	1288	1247

TABLE IV - TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Continued

(e) $s/R = 0.57$; $\phi = 242.00^\circ$

Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$			Temperature, $^{\circ}\text{K}$, at $x =$			Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$		
	0.0330 cm	0.1880 cm	0.3376 cm	0.5080 cm	0.0330 cm	0.1880 cm	0.3376 cm	0.5080 cm	0.0330 cm	0.1880 cm
1648.07	300	300	---	---	1652.12	1107	1058	1008	1008	1008
1648.26	373	321	300	300	1652.41	1129	1085	1040	1040	1040
1648.36	419	370	349	318	1652.51	1147	1099	1062	1052	1052
1648.46	466	413	382	382	1652.60	1158	1105	1084	1058	1058
1648.55	468	413	405	388	1652.70	1163	1122	1093	1078	1078
1648.65	540	490	453	431	1652.80	1149	1132	1103	1077	1077
1648.75	545	484	450	427	1652.90	1171	1128	1105	1099	1099
1648.94	610	534	474	438	1653.00	1192	1141	1120	1100	1100
1649.03	624	550	523	507	1653.09	1174	1136	1126	1120	1120
1649.13	627	554	530	499	1653.19	1194	1129	1129	1106	1106
1649.23	661	584	543	535	1653.38	1201	1159	1130	1124	1124
1649.32	690	617	582	567	1653.48	1214	1181	1146	1134	1134
1649.42	695	639	607	584	1653.57	1203	1151	1136	1132	1132
1649.51	706	653	617	592	1653.67	1186	1177	1137	1129	1129
1649.61	727	674	617	628	1653.77	1214	1185	1158	1142	1142
1649.71	759	691	656	639	1653.87	1209	1201	1171	1163	1163
1649.80	779	715	680	647	1653.96	1243	1208	1181	1158	1158
1649.90	794	731	689	676	1654.06	1209	1182	1180	1153	1153
1650.00	808	747	778	747	1654.16	1256	1212	1187	1191	1191
1650.09	801	---	---	---	1654.25	1236	1201	1188	1151	1151
1650.19	850	782	768	734	1654.35	1264	1221	1204	1183	1183
1650.29	878	839	783	756	1654.55	1255	1228	1183	1202	1202
1650.38	921	848	802	786	1654.64	1251	1225	1221	1207	1207
1650.48	913	842	815	796	1654.74	1257	1232	1217	1198	1198
1650.57	929	867	840	791	1654.84	1275	1241	1232	1188	1188
1650.67	949	888	840	834	1654.94	1255	1222	1196	1191	1191
1650.77	948	887	857	832	1655.03	1235	1217	1223	1223	1223
1650.86	985	920	859	---	1655.13	1283	1267	1256	1232	1232
1650.96	993	933	880	860	1655.23	1280	1267	1244	1244	1244
1651.06	1005	957	915	892	1655.33	1279	1272	1253	1240	1240
1651.15	999	927	910	893	1655.42	1260	1256	1237	1221	1221
1651.25	1013	956	908	892	1655.52	1260	1241	1241	1235	1235
1651.35	1019	973	---	918	1655.62	1262	1236	1218	1231	1231
1651.44	1054	988	949	939	1655.72	1275	1275	1245	1245	1245
1651.54	1058	998	976	950	1655.81	---	---	1247	1265	1265
1651.64	1077	1021	992	971	1655.91	1272	1259	1249	1236	1236
1651.73	1076	1027	985	965	1656.01	1287	1287	1267	1231	1231
1651.93	1103	1045	1005	993	1656.11	1280	1283	1248	1253	1253
1652.02	---	1033	992	1000	1656.20	1272	1283	1259	1252	1252

TABLE IV.- TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Continued

(f) $s/R = 0.87; \phi = 28.00^\circ$ (g) $s/R = 0.87; \phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$		Time, sec	Temperature, °K, at $x =$		Time, sec	Temperature, °K, at $x =$		
	0.0315 cm	0.1839 cm		0.0315 cm	0.1839 cm		0.0320 cm	0.3325 cm	0.5080 cm
1648.07	300	300	1652.12	1146	1064	1648.07	300	300	300
1648.26	379	309	1652.41	1152	1114	1648.17	325	331	340
1648.36	434	384	1652.51	1147	1101	1648.26	367	---	---
1648.46	493	438	1652.60	1193	1134	1648.36	428	364	349
1648.55	452	384	1652.70	---	1128	1648.46	466	399	382
1648.75	528	472	1652.80	---	1141	1648.55	493	393	382
1648.94	594	518	1652.90	1202	1146	1648.65	526	464	433
1649.03	631	560	1653.00	1194	1147	1648.75	565	461	421
1649.13	633	562	1653.09	1213	1174	1648.94	621	521	505
1649.23	638	576	1653.19	1176	1182	1649.03	639	563	531
1649.32	704	625	1653.38	1228	1168	1649.13	670	579	535
1649.42	711	634	1653.48	1263	1191	1649.23	699	576	570
1649.51	730	657	1653.57	1215	1177	1649.32	704	614	592
1649.61	755	698	1653.67	1220	1177	1649.42	733	624	603
1649.71	768	716	1653.77	1236	1202	1649.51	736	611	590
1649.80	779	718	1653.87	1249	1209	1649.61	749	660	623
1649.90	832	747	1653.96	1252	1223	1649.71	782	673	639
1650.00	806	737	1654.06	1237	1198	1649.80	802	696	683
1650.09	891	805	1654.16	1247	1218	1649.90	---	718	691
1650.19	883	808	1654.25	1259	1252	1650.00	---	724	684
1650.29	907	839	1654.35	1285	1228	1650.09	---	745	---
1650.38	946	872	1654.55	1293	1248	1650.19	---	776	774
1650.48	919	850	1654.64	1296	1248	1650.29	---	810	769
1650.57	937	873	1654.74	---	1257	1650.38	---	839	807
1650.67	971	897	1654.84	1293	1275	1650.48	---	831	807
1650.77	978	918	1654.94	1277	1259	1650.57	---	848	821
1650.86	999	943	1655.03	1316	1264	1650.67	---	880	851
1650.96	1021	956	1655.13	1301	1280	1650.77	---	887	857
1651.06	1043	965	1655.23	1313	1280	1650.86	---	912	892
1651.15	1030	959	1655.33	1322	1289	1650.96	---	928	885
1651.25	1039	978	1655.42	1301	1279	1651.06	---	943	915
1651.35	1062	965	1655.52	1305	1276	1651.15	---	959	921
1651.44	1075	994	1655.62	1288	1272	1651.25	---	964	942
1651.54	1075	1015	1655.72	1334	1291	1651.35	---	959	943
1651.64	1107	1027	1655.81	1347	1292	1651.44	---	979	963
1651.73	1099	1047	1655.91	1299	1295	1651.54	---	1009	970
1651.93	1116	1045	1656.01	1327	1309	1651.64	---	1015	986
1652.02	1131	1069	1656.11	1328	---	1651.73	---	1035	1001
						1651.93	---	1071	1043
						1652.02	---	---	1038
						1652.12	---	1087	1046
						1652.41	---	1112	1075
						1652.51	---	1103	1072
						1652.60	---	1125	---
						1652.70	---	1134	1107
						1652.80	---	1135	1120
						1652.90	---	1128	1116
						1653.00	---	1153	1129
						1653.09	---	1177	1147
						1653.19	---	1168	---

TABLE IV.- TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Continued

(h) $s/R = 0.87$; $\phi = 242.000$

Time, sec	Temperature, °K, at $x =$			Temperature, °K, at $x =$			Temperature, °K, at $x =$		
	0.0356 cm	0.1880 cm	0.3386 cm	0.5080 cm	0.0356 cm	0.1880 cm	0.3386 cm	0.5080 cm	
1648.07	300	300	300	---	1652.12	1107	1075	---	994
1648.17	351	---	---	---	1652.41	1137	1103	1079	1034
1648.26	382	309	309	300	1652.51	---	1078	1058	1041
1648.36	450	376	357	345	1652.60	1169	1113	1099	1054
1648.46	471	424	399	373	1652.70	1160	1136	1099	1078
1648.55	474	415	409	392	1652.80	1176	1114	1085	1063
1648.65	521	490	459	445	1652.90	1175	1136	1113	1095
1648.75	528	476	441	439	1653.00	1180	1155	1100	1114
1648.84	607	543	510	487	1653.09	1194	1162	1136	---
1649.03	650	589	525	503	1653.19	1197	1155	1120	1102
1649.13	635	573	532	497	1653.38	1198	1159	1141	1120
1649.23	657	592	560	522	1653.48	1196	1199	1142	1140
1649.32	688	640	592	567	1653.57	1209	1159	1162	1151
1649.42	714	639	589	578	1653.67	1207	1171	1148	1129
1649.51	706	641	587	585	1653.77	1220	1185	1160	1154
1649.61	739	679	628	623	1653.87	1224	1192	1187	1159
1649.71	754	697	648	629	1653.96	1249	1212	1179	1166
1649.80	769	715	685	---	1654.06	1228	1194	1180	1151
1649.90	805	736	699	674	1654.16	---	1199	1187	1175
1650.00	824	728	710	684	1654.25	1243	1212	1197	1192
1650.09	856	792	745	731	1654.35	1267	1228	1210	1181
1650.19	860	804	749	726	1654.55	1264	1239	1204	1210
1650.29	897	837	807	767	1654.64	1257	1232	1202	1175
1650.38	915	872	815	800	1654.74	1257	1239	1219	1219
1650.48	913	858	817	780	1654.84	1268	1268	1213	1232
1650.57	935	879	834	810	1654.94	1239	1214	1199	1196
1650.67	966	920	846	806	1655.03	1277	1228	1217	1204
1650.77	964	---	867	827	1655.13	1264	1260	1253	1225
1650.86	997	929	906	884	1655.23	1280	1253	1241	1231
1650.96	993	944	905	878	1655.33	---	1276	1231	1218
1651.06	1019	951	910	890	1655.42	1267	1231	1231	1215
1651.15	1015	959	915	883	1655.52	1267	1253	1231	1215
1651.25	1039	980	950	908	1655.62	1263	1249	1227	1212
1651.35	1039	987	928	895	1655.72	1272	1265	1236	1239
1651.44	1059	1008	971	935	1655.81	1288	1263	1272	1259
1651.54	1075	1020	966	946	1655.91	1279	1272	1233	1229
1651.64	1089	1041	992	---	1656.01	1303	---	1257	1244
1651.73	1076	1041	1005	991	1656.11	1293	1248	1264	1240
1651.93	1118	1071	1019	1001	1656.20	1296	1272	1279	1299
1652.02	1111	1064	1027	983					1285

Time, sec	Temperature, °K, at $x =$			Temperature, °K, at $x =$			Temperature, °K, at $x =$		
	0.0356 cm	0.1880 cm	0.3386 cm	0.5080 cm	0.0356 cm	0.1880 cm	0.3386 cm	0.5080 cm	
1656.30	1285	1249	1252	1259	1656.40	1305	1245	1292	1255
1656.50	1289	1289	1279	1259	1656.59	1305	1259	1269	1256
1656.69	1289	1289	1275	1275	1656.79	1380	1271	1275	1257
1656.89	1285	1255	1277	1255	1657.08	1281	1243	1288	1277
1657.18	1287	1287	1271	1280	1657.18	1281	1271	1280	1276
1657.28	1281	1281	1261	1280	1657.28	1281	1261	1280	1261
1657.38	---	1265	1272	---	1657.57	1273	1280	1285	1305
1657.66	1289	1289	1285	1285	1657.86	1289	1285	1285	1265
1657.96	1275	1275	1275	1279	1657.96	1275	1275	1280	1279
1658.06	1285	1312	1291	1291	1658.06	1285	1312	1301	1295
1658.16	1284	1287	1280	1271	1658.25	1272	1305	1292	1309
1658.25	1272	1272	1272	1272	1658.35	1265	1281	1301	1295
1658.45	1285	1285	1285	1285	1658.45	1285	1285	1286	1276
1658.55	1273	1300	1300	1300	1658.55	1273	1300	1300	1277
1658.74	1275	1237	1237	1237	1658.74	1275	1275	1239	1304
1658.84	1264	1264	1264	1264	1658.84	1264	1264	1297	1281
1659.04	1261	1261	1261	1261	1659.04	1261	1261	1272	1281
1659.13	1273	1273	1280	1280	1659.13	1273	1273	1283	1263
1659.33	1233	1233	1233	1233	1659.33	1233	1233	1276	1271
1659.53	1257	1257	1257	1257	1659.53	1257	1257	1280	1308
1659.72	1248	1248	1248	1248	1659.72	1248	1248	1281	1264
1659.92	1232	1232	1232	1232	1659.92	1232	1232	1277	1264
1660.01	1247	1247	1247	1247	1660.01	1247	1247	1264	1297
1660.31	1277	1313	1313	1313	1660.31	1277	1313	1327	1294
1660.41	1264	1264	1264	1264	1660.41	1264	1264	1283	1284
1660.50	---	1267	1267	1267	1660.50	---	1267	1267	1276
1660.60	1261	1261	1261	1261	1660.60	1261	1261	1261	1252
1660.80	---	1261	1261	1261	1660.80	---	1261	1261	1285
1660.90	1272	1272	1272	1272	1660.90	1272	1272	1322	1305
1660.99	1268	1268	1268	1268	1660.99	1268	1268	1302	1311
1661.09	1268	1268	1268	1268	1661.09	1268	1268	1321	1271
1661.19	1240	1240	1240	1240	1661.19	1240	1240	1299	1295
1661.29	1256	1256	1256	1256	1661.29	1256	1256	1256	1301

TABLE IV.- TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Continued

(i) $s/R = 1.00; \phi = 28.00^\circ$ (j) $s/R = 1.00; \phi = 146.25^\circ$

Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$			Time, sec	Temperature, °K, at $x =$		
	0.0330 cm	0.1831 cm	0.5080 cm		0.0330 cm	0.1831 cm	0.5080 cm		0.1814 cm	0.3363 cm	0.5080 cm
1648.07	300	300	300	1652.12	436	431	419	1648.26	300	300	300
1648.26	303	300	300	1652.41	---	---	453	1648.36	305	300	---
1648.36	305	305	300	1652.51	453	464	442	1648.46	320	---	309
1648.46	---	335	323	1652.60	453	462	442	1648.55	320	327	314
1648.55	300	300	300	1652.70	463	469	---	1648.65	351	---	324
1648.65	345	330	300	1652.80	445	---	456	1648.75	318	315	---
1648.75	318	303	309	1652.90	461	477	455	1648.94	341	324	339
1648.94	330	324	318	1653.00	454	477	474	1649.03	361	365	361
1649.03	353	359	346	1653.09	475	481	481	1649.13	345	345	336
1649.13	309	300	305	1653.19	470	472	470	1649.23	356	360	336
1649.23	324	309	318	1653.38	481	481	472	1649.32	367	371	384
1649.32	371	350	341	1653.48	468	474	490	1649.42	359	354	377
1649.42	356	344	341	1653.57	484	486	489	1649.51	341	351	366
1649.51	341	333	336	1653.67	482	498	484	1649.61	362	333	389
1649.61	351	357	348	1653.77	478	495	474	1649.71	339	361	410
1649.71	351	343	343	1653.87	501	499	503	1649.80	378	372	415
1649.80	345	330	327	1653.96	499	509	507	1649.90	396	390	429
1649.90	359	370	370	1654.06	498	494	492	1650.00	365	362	422
1650.00	341	341	---	1654.16	503	526	515	1650.09	---	---	470
1650.09	---	---	370	1654.25	510	526	524	1650.19	409	403	457
1650.19	385	397	368	1654.35	517	536	533	1650.29	---	---	492
1650.29	410	414	408	1654.55	530	527	514	1650.38	---	---	502
1650.38	419	410	396	1654.64	519	539	531	1650.48	410	396	461
1650.48	377	385	385	1654.74	514	533	516	1650.57	399	395	472
1650.57	389	407	368	1654.84	533	530	514	1650.67	403	427	468
1650.67	385	389	377	1654.94	522	524	518	1650.77	422	436	478
1650.77	397	408	416	1655.03	530	533	527	1650.86	429	419	508
1650.86	---	399	393	1655.13	547	550	550	1650.96	419	419	511
1650.96	393	407	384	1655.23	544	558	516	1651.06	447	433	519
1651.06	419	419	415	1655.33	534	548	531	1651.15	431	433	532
1651.15	416	424	421	1655.42	545	536	534	1651.25	438	449	536
1651.25	413	425	419	1655.52	527	544	542	1651.44	445	445	547
1651.35	395	403	391	1655.62	545	551	534	1651.54	438	455	566
1651.44	393	409	401	1655.72	532	566	535	1651.64	435	459	566
1651.54	397	415	407	1655.81	562	572	---	1651.73	461	467	---
1651.64	406	421	421	1655.91	534	---	---	1651.93	466	468	609
1651.73	425	447	425	1656.01	556	---	---	1652.02	491	483	630
1651.93	454	436	416	1656.11	542	---	---	1652.12	459	468	611
1652.02	448	464	439	1656.20	553	---	---	1652.41	476	478	643
								1652.51	492	475	647
								1652.60	487	493	657
								1652.70	500	497	689
								1652.80	503	498	681
								1652.90	491	486	---
								1653.00	499	---	---
								1653.09	519	---	---

TABLE IV.- TEMPERATURES RECORDED IN THIRD BERYLLIUM CALORIMETER LAYER - Concluded

(k) $s/R = 1.00$; $\phi = 242.00^\circ$

Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$				Temperature, $^{\circ}\text{K}$, at $x =$				Time, sec	Temperature, $^{\circ}\text{K}$, at $x =$			
	0.0300 cm	0.1824 cm	0.3396 cm	0.5080 cm	0.0300 cm	0.1824 cm	0.3396 cm	0.5080 cm		0.0300 cm	0.1824 cm	0.3396 cm	0.5080 cm
1648.26	300	300	300	300	1652.12	431	436	419	436	1656.20	573	587	568
1648.36	---	305	300	---	1652.41	476	459	459	442	1656.30	570	576	565
1648.46	320	329	327	320	1652.51	459	439	445	459	1656.40	601	596	562
1648.55	305	311	300	300	1652.80	453	---	450	450	1656.50	585	598	581
1648.65	---	343	---	336	1652.70	486	477	461	477	1656.59	600	606	562
1648.75	321	303	311	318	1652.80	---	418	462	470	1656.69	592	603	565
1648.94	333	323	324	330	1652.90	455	446	463	---	1656.79	609	615	571
1649.03	356	353	344	341	1653.00	485	493	454	483	1656.89	600	615	563
1649.13	341	333	320	318	1653.09	481	484	472	481	1657.08	627	629	589
1649.23	341	333	315	339	1653.19	478	472	453	476	1657.18	609	645	587
1649.32	365	359	341	361	1653.38	484	481	472	469	1657.28	620	590	596
1649.42	367	348	348	339	1653.48	484	487	482	482	1657.38	617	644	584
1649.51	336	336	327	---	1653.57	494	484	475	472	1657.67	636	660	625
1649.61	357	339	318	333	1653.67	516	495	503	495	1657.86	636	619	614
1649.71	333	330	345	336	1653.77	490	484	476	487	1657.96	636	670	597
1649.80	354	351	354	357	1653.87	507	493	487	499	1658.06	650	673	607
1649.90	373	390	378	350	1653.96	514	507	499	493	1658.16	659	709	636
1650.00	359	356	338	347	1654.06	500	498	486	506	1658.25	633	685	---
1650.09	---	401	---	1654.16	526	515	503	509	1658.35	651	689	621	621
1650.19	401	395	395	---	1654.25	526	530	516	518	1658.45	645	695	617
1650.29	---	400	406	---	1654.35	539	519	523	536	1658.55	639	689	606
1650.38	---	414	400	---	1654.55	522	535	510	527	1658.74	665	678	625
1650.48	385	394	388	371	1654.64	533	542	518	531	1658.84	650	694	619
1650.57	395	399	372	381	1654.74	552	541	527	530	1659.04	647	701	623
1650.67	409	409	394	383	1654.84	535	527	533	522	1659.13	660	701	638
1650.77	416	385	397	408	1654.94	530	541	516	530	1659.33	659	714	---
1650.86	413	425	413	399	1655.03	535	544	539	541	1659.53	---	722	639
1650.96	413	399	387	407	1655.13	558	556	558	558	1659.72	---	726	634
1651.06	409	427	413	415	1655.23	561	558	539	542	1659.92	---	649	634
1651.15	427	425	421	410	1655.33	572	561	545	545	1660.01	---	728	663
1651.25	435	407	410	415	1655.42	550	553	525	542	1660.31	---	691	691
1651.35	397	418	391	---	1655.52	582	556	556	539	1660.41	---	744	673
1651.44	429	425	399	405	1655.62	572	557	543	559	1660.50	---	746	674
1651.54	449	453	433	427	1655.72	543	541	557	541	1660.60	---	747	665
1651.64	415	427	400	406	1655.81	553	553	553	553	1660.90	---	678	678
1651.73	---	450	428	425	1655.91	568	557	551	548	1661.09	---	684	684
1651.93	454	450	445	440	1656.01	566	558	558	569	1661.19	---	710	710
1652.02	459	467	461	456	1656.11	580	561	558	558	1661.29	---	680	680

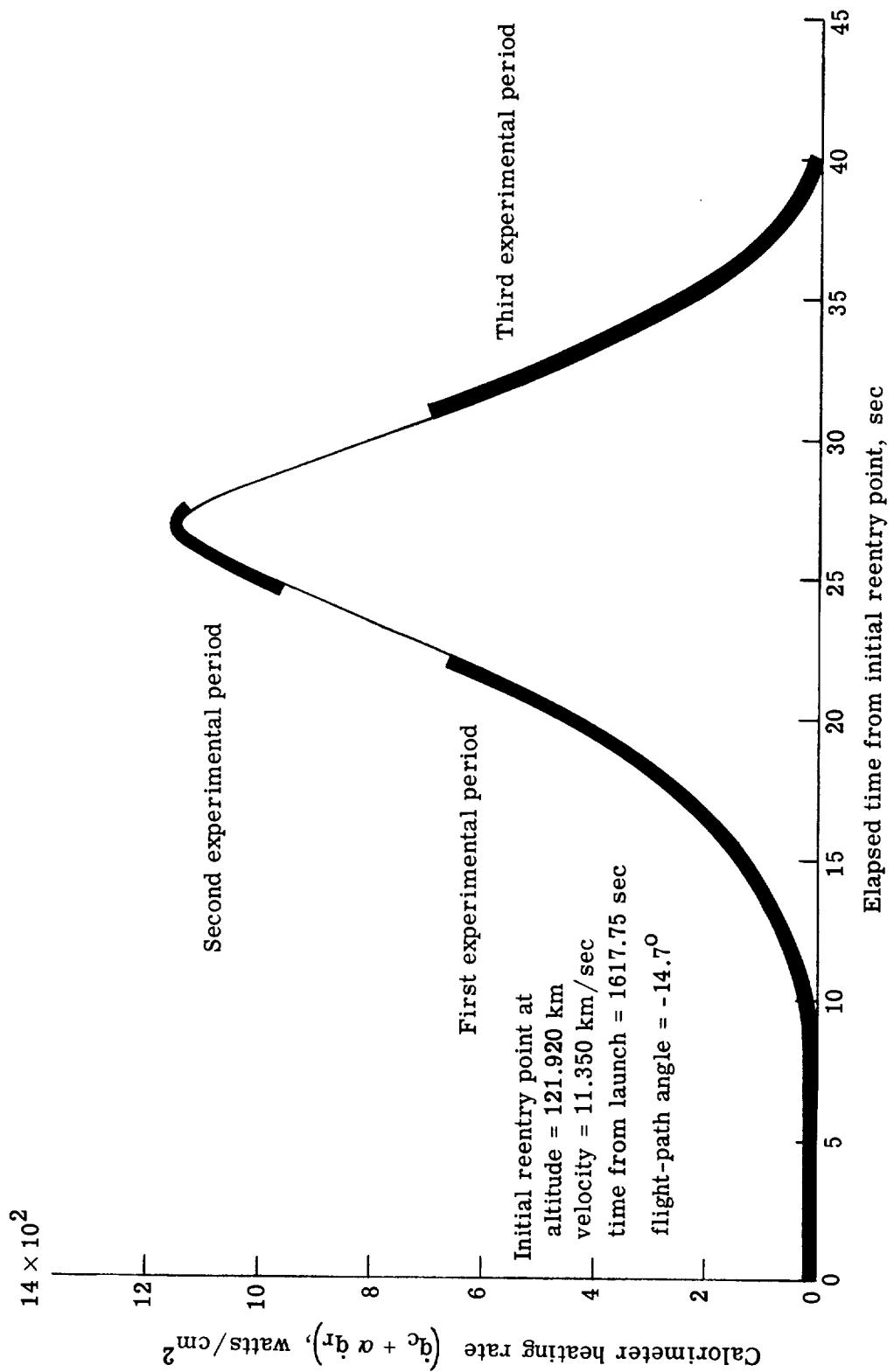


Figure 1.- Typical forebody heating rate and experimental data periods during Project Fire II reentry.

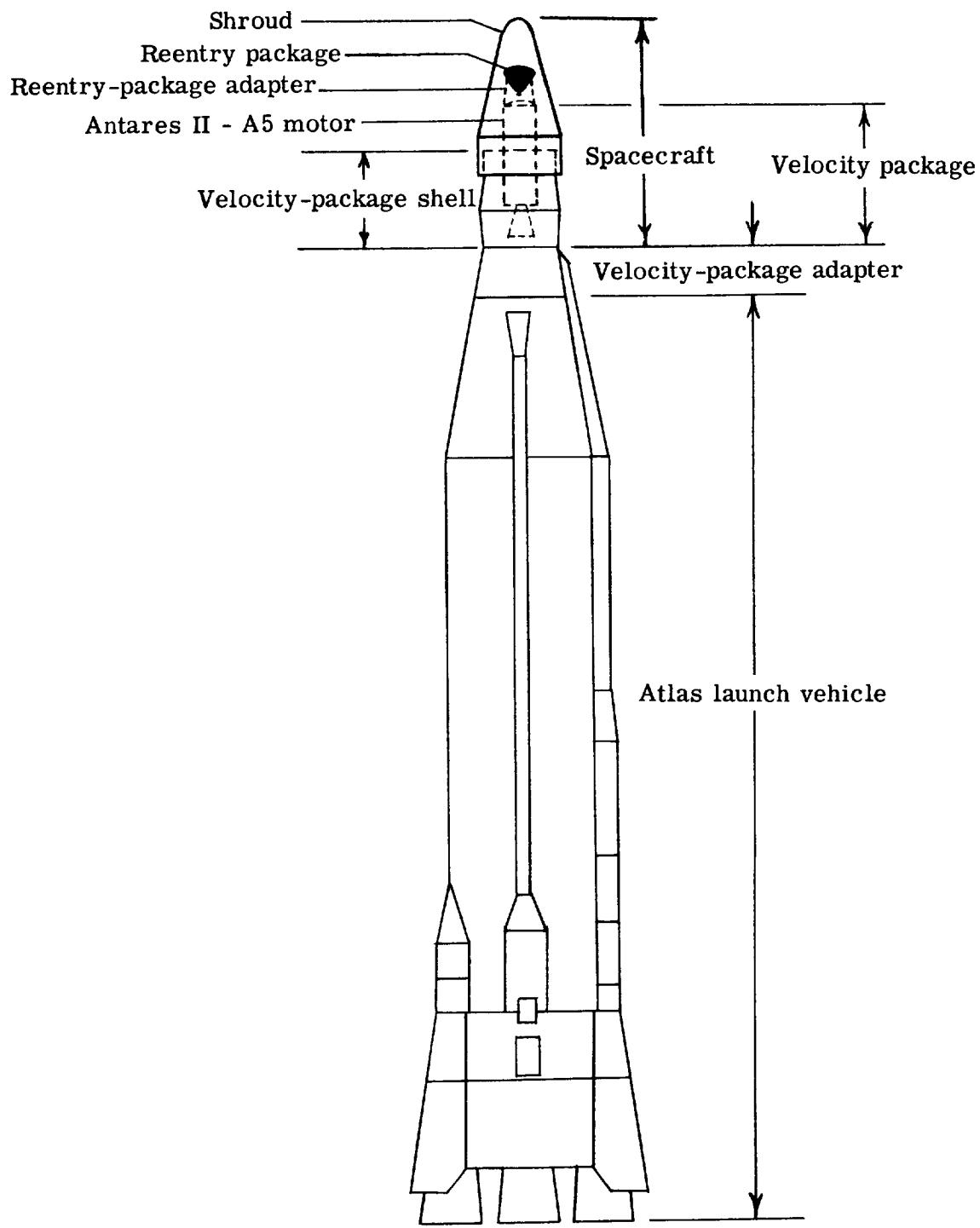


Figure 2.- Sketch of Project Fire space vehicle.

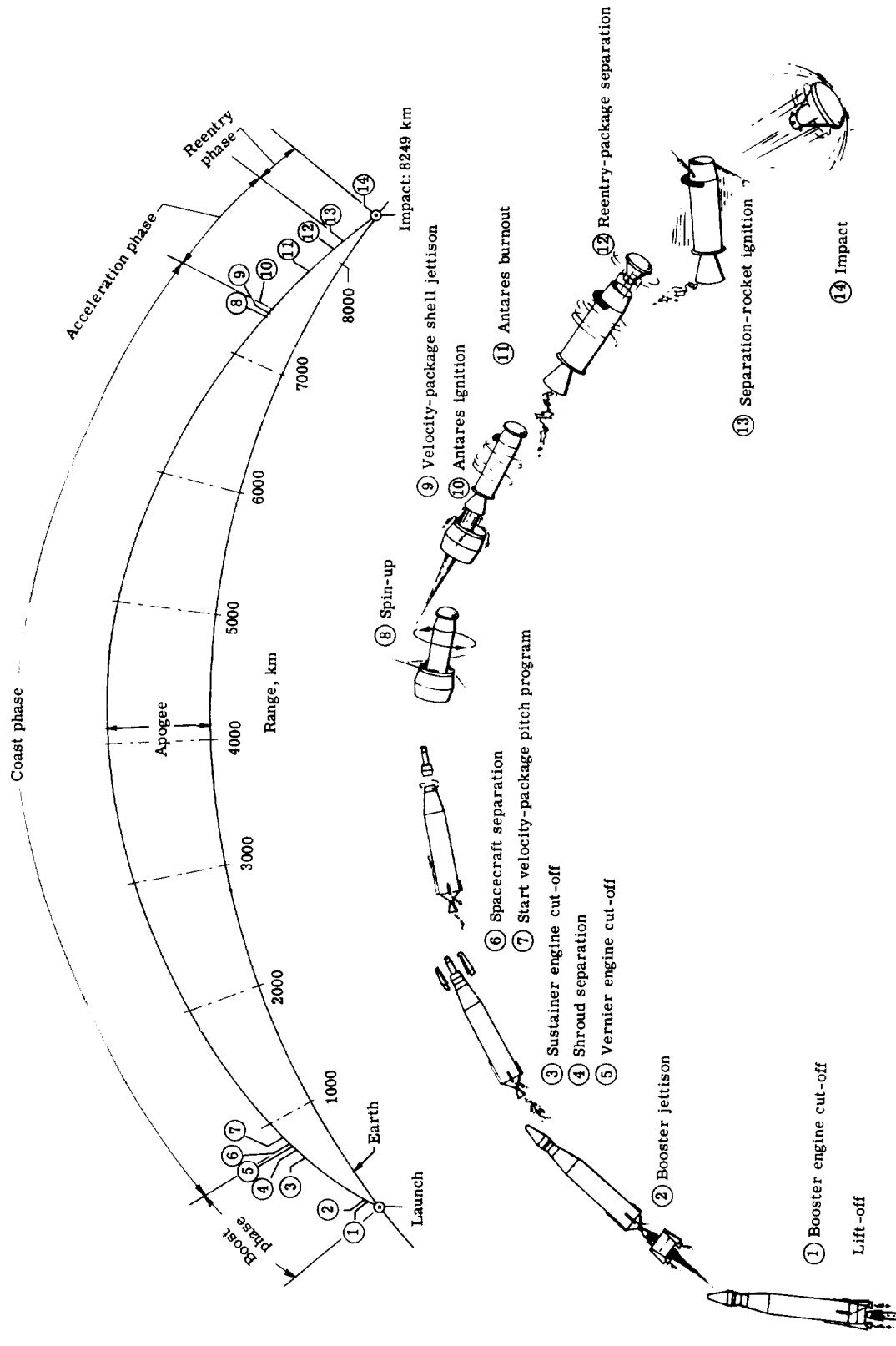


Figure 3.: Project Fire vehicle trajectory and flight sequence of events.

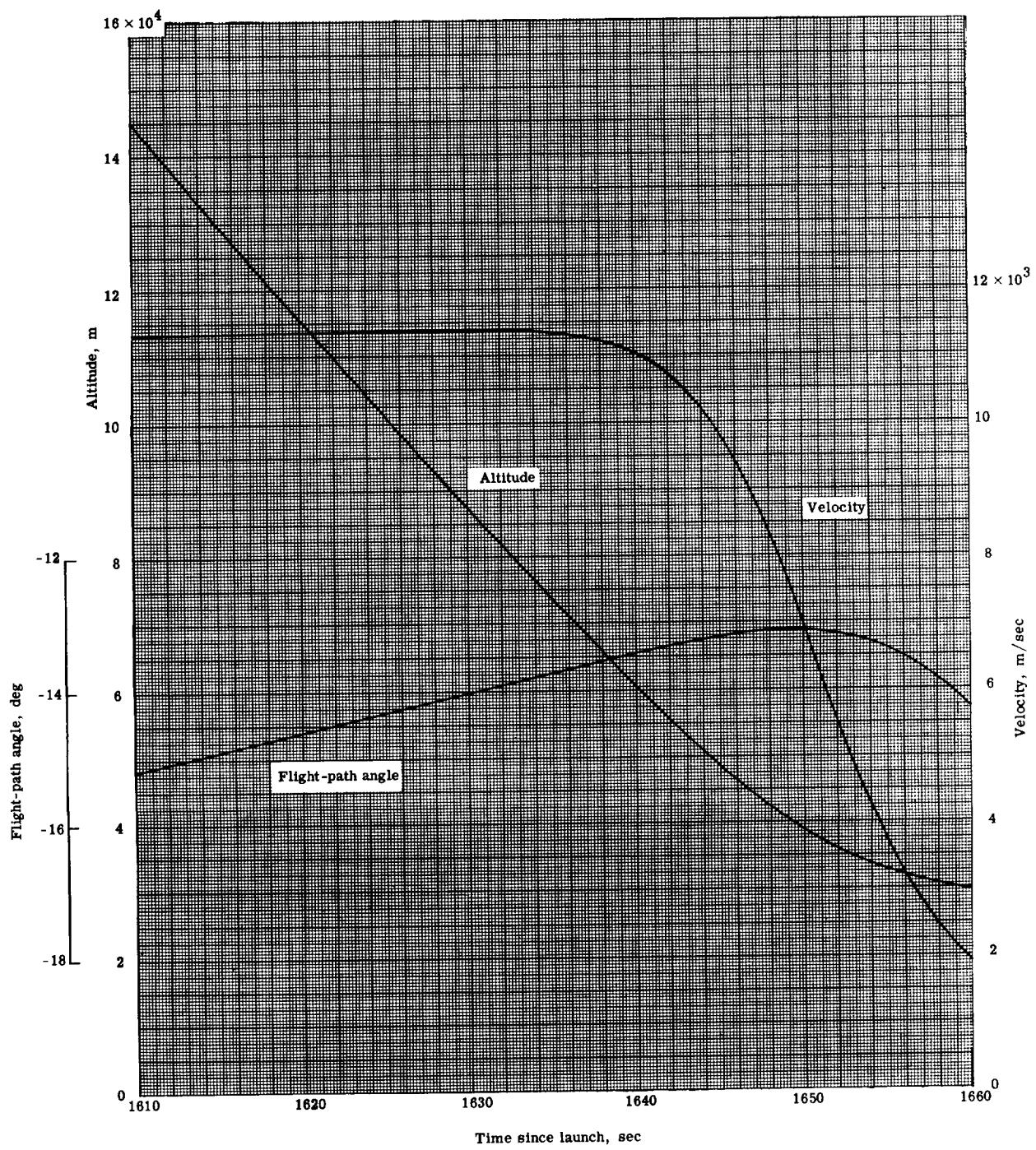
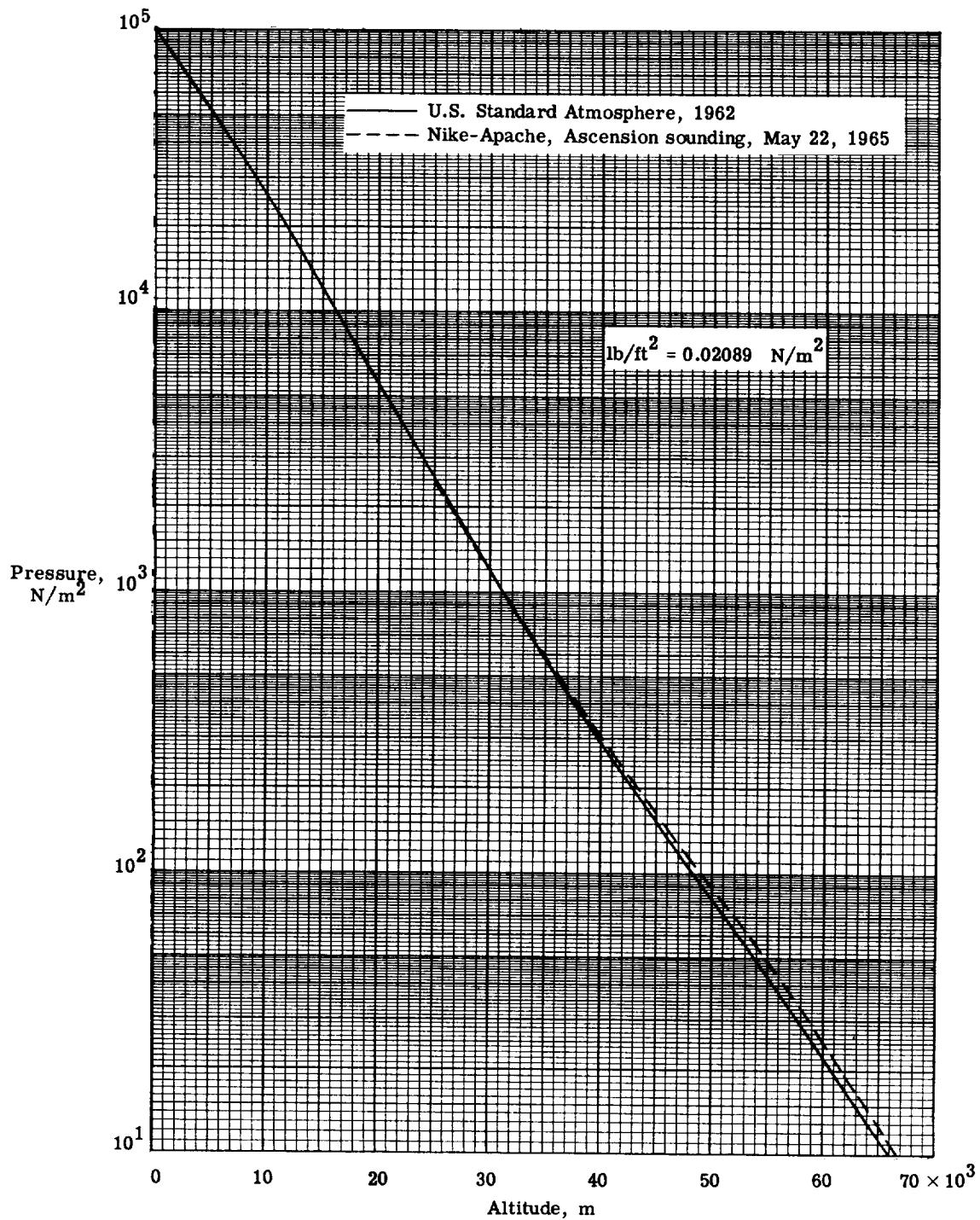
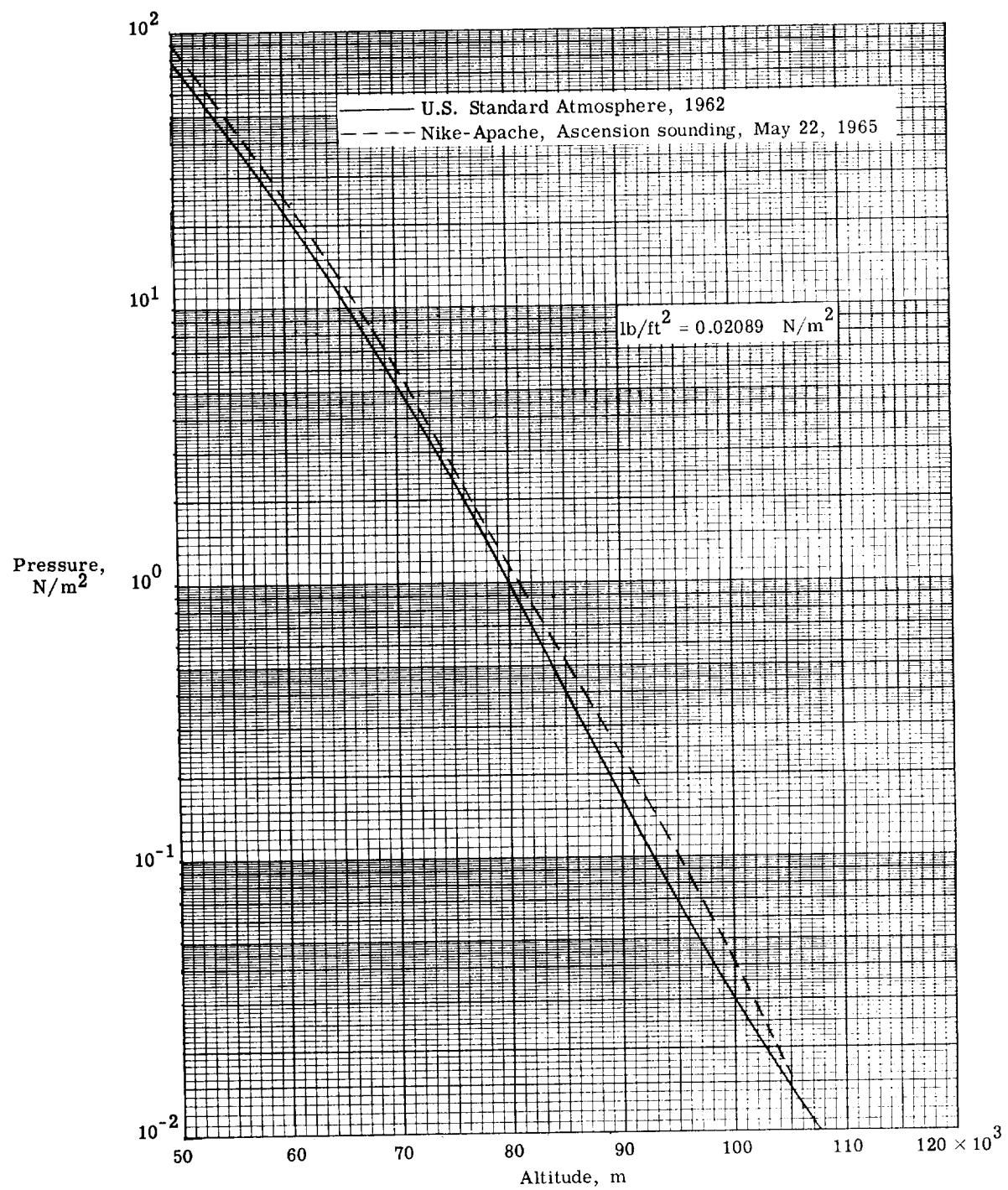


Figure 4.- Variation of altitude, velocity, and flight-path angle with time for Fire II reentry.



(a) Variation of pressure with altitude.

Figure 5.- Ambient atmospheric conditions during the Fire II reentry as obtained from a sounding rocket over Ascension Island.



(a) Concluded.

Figure 5.- Continued.

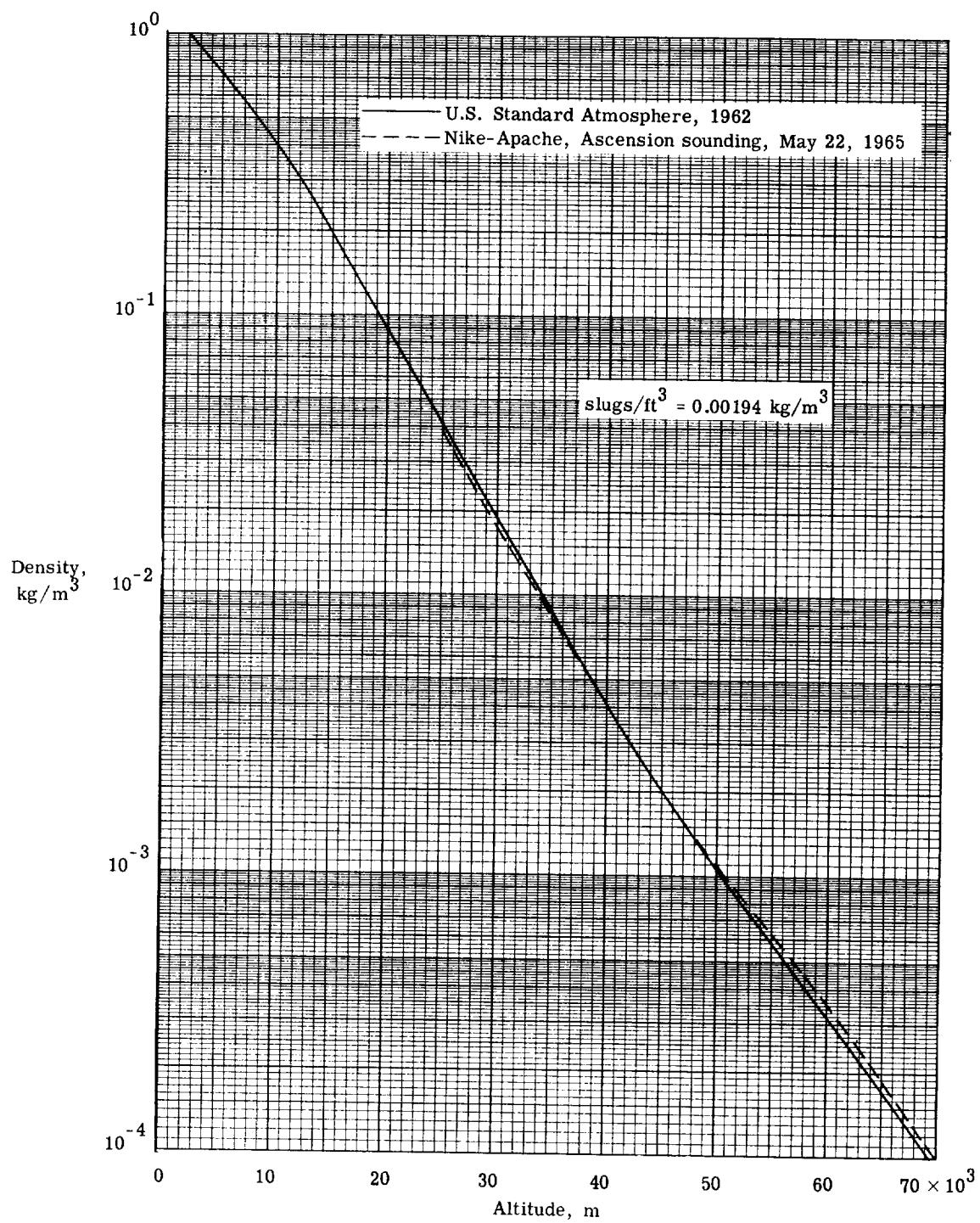
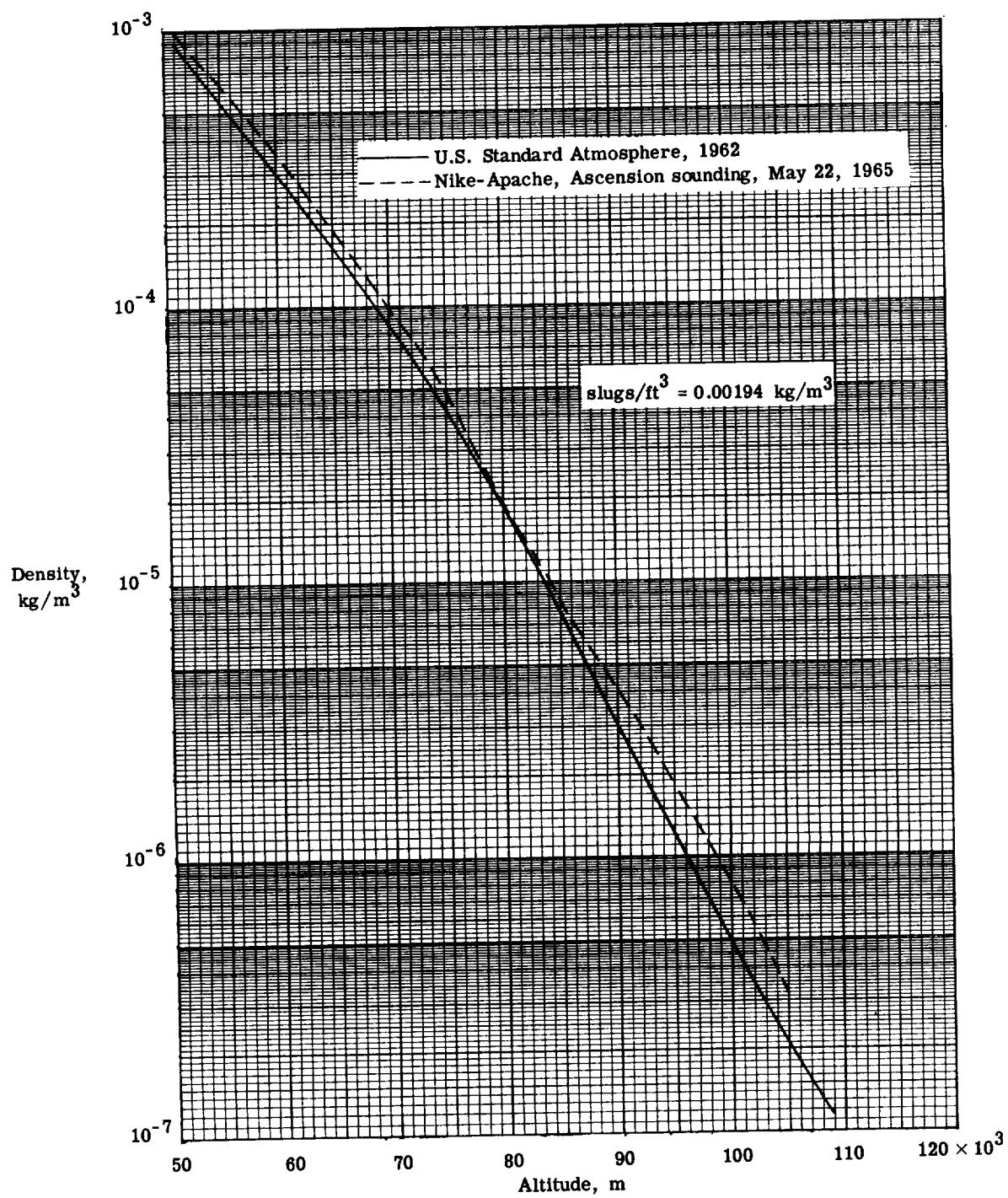
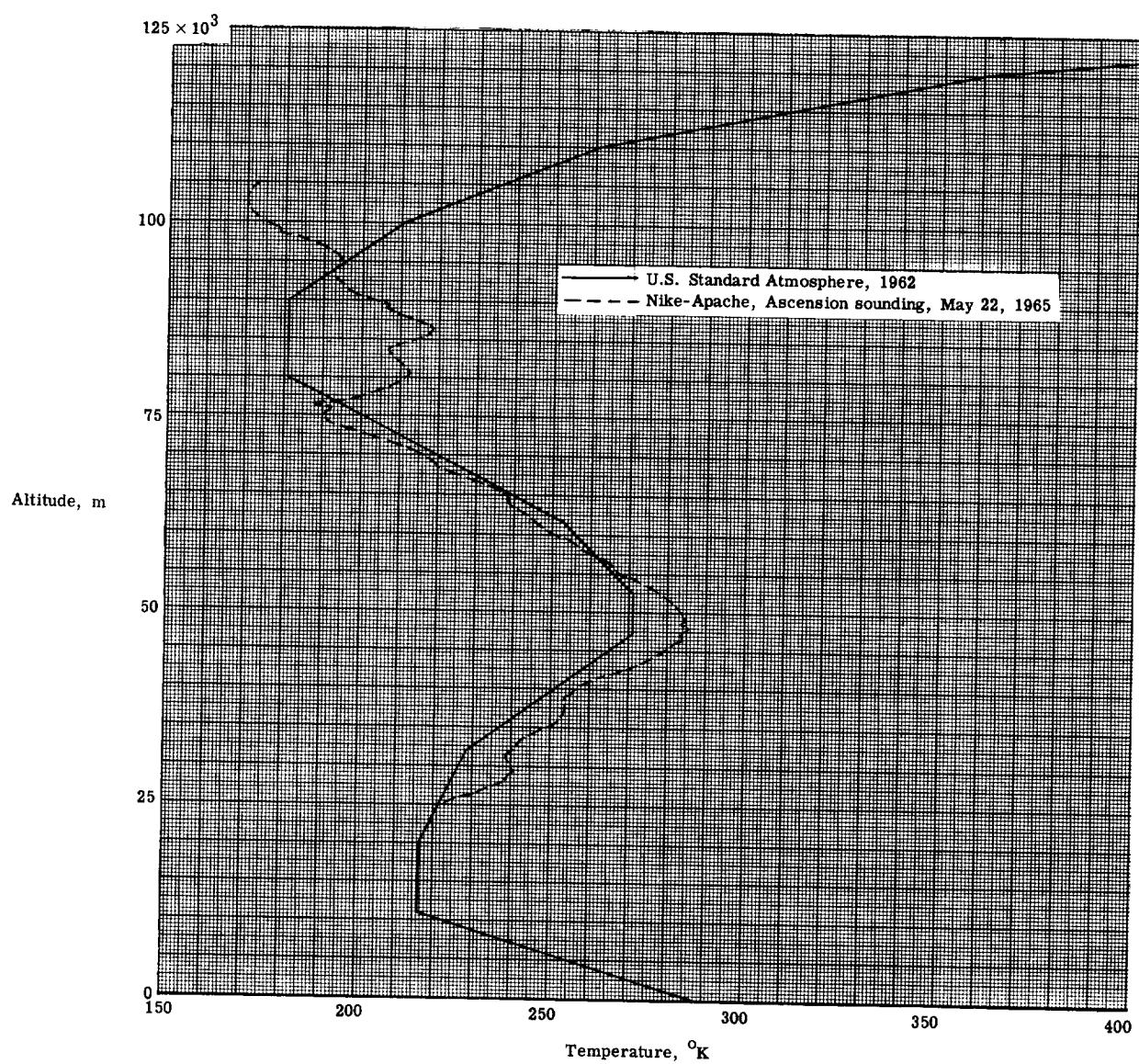


Figure 5.- Continued.



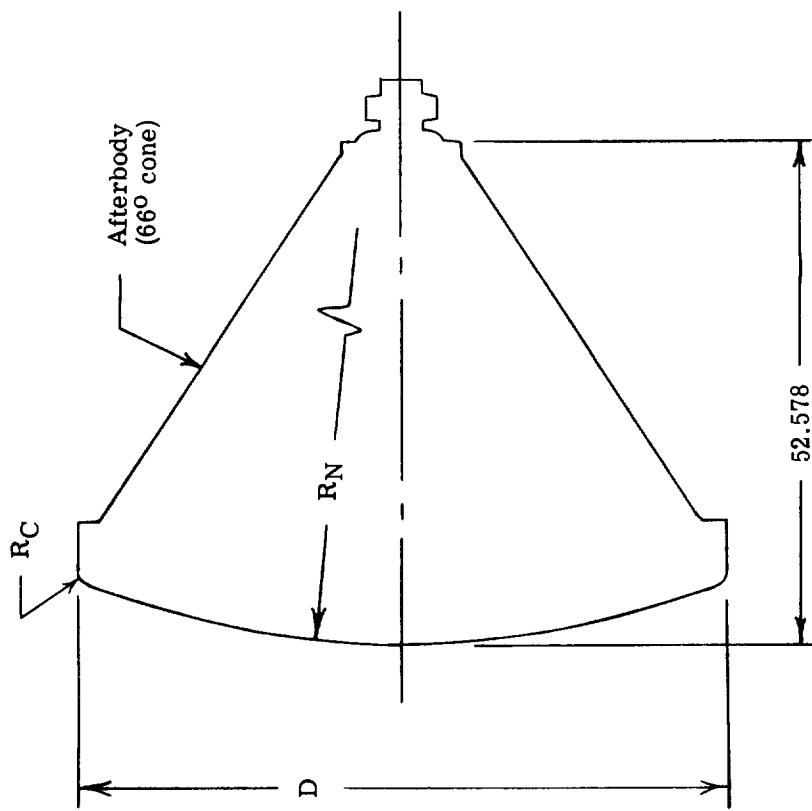
(b) Concluded.

Figure 5.- Continued.



(c) Variation of temperature with altitude.

Figure 5.- Concluded.



Experiment period	Reentry package dimensions		
	D	R_N	R_C
1	67.16	93.47	1.02
2	62.99	80.52	3.56
3	58.70	70.21	0.61

Figure 6.- Reentry package dimensions. (All dimensions are in centimeters except as noted.)

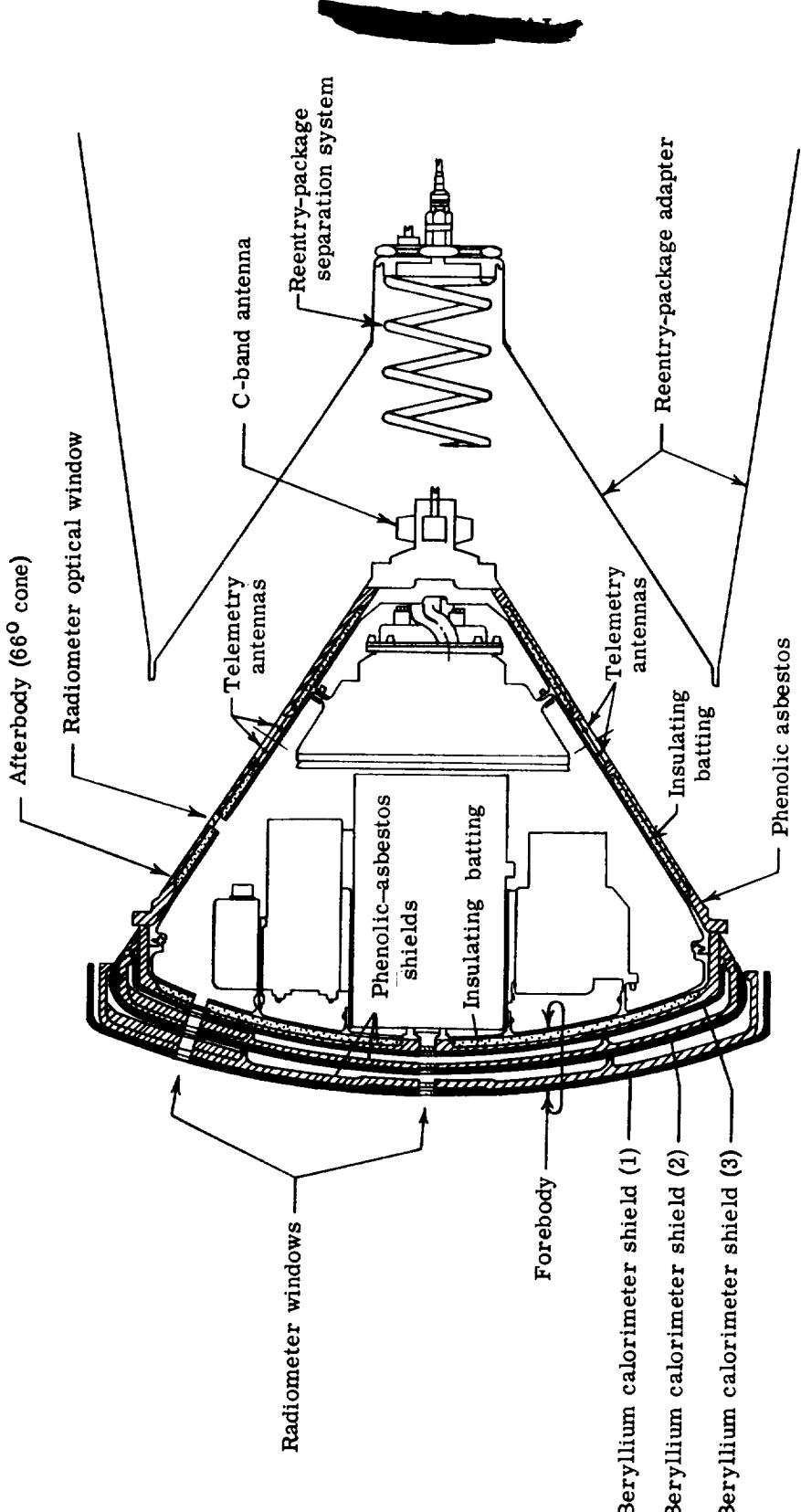


Figure 7.- Sketch of Project Fire reentry package and adapter illustrating layered arrangement of forebody heat shielding.

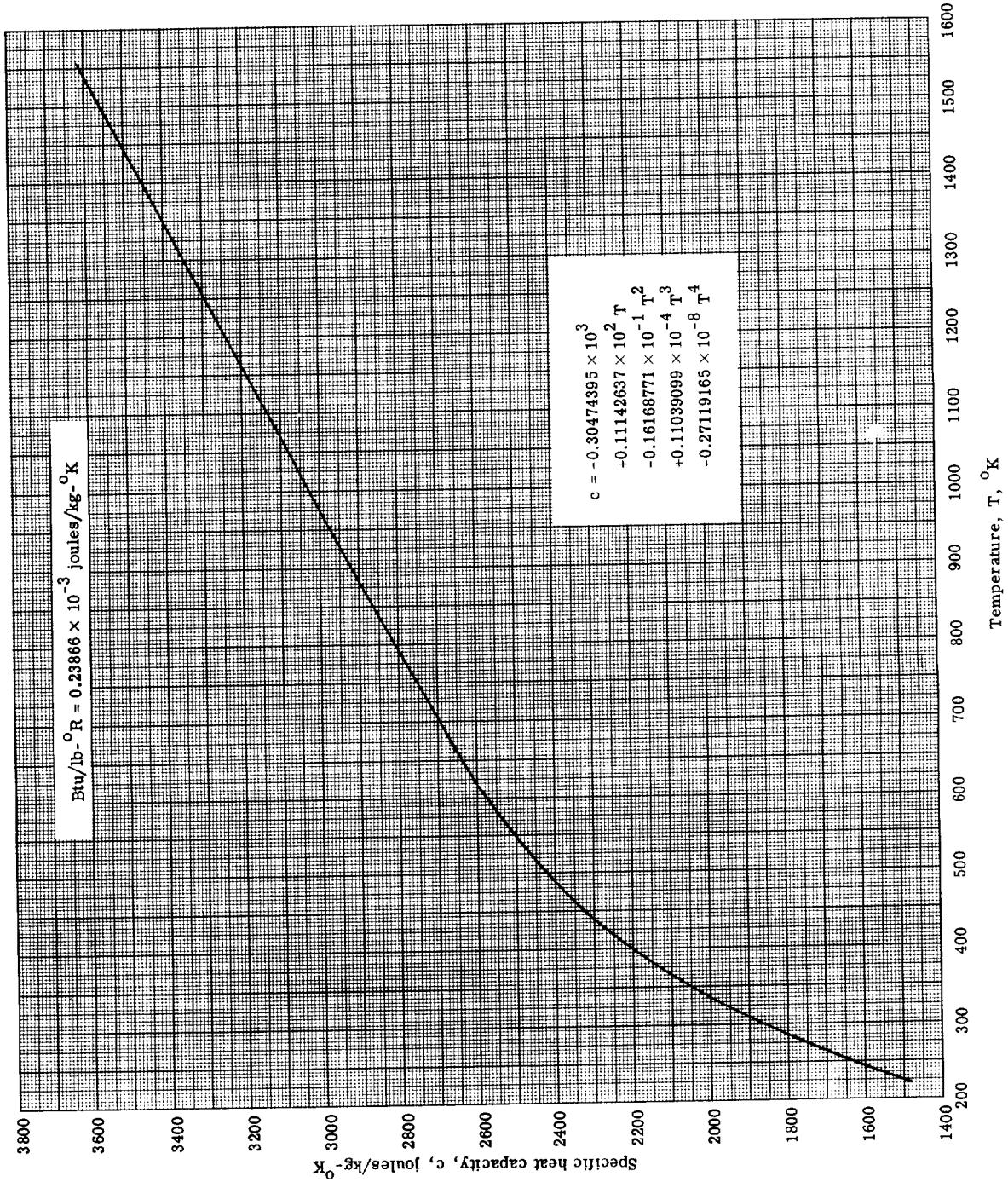


Figure 8.- Variation of specific heat capacity of beryllium with temperature.

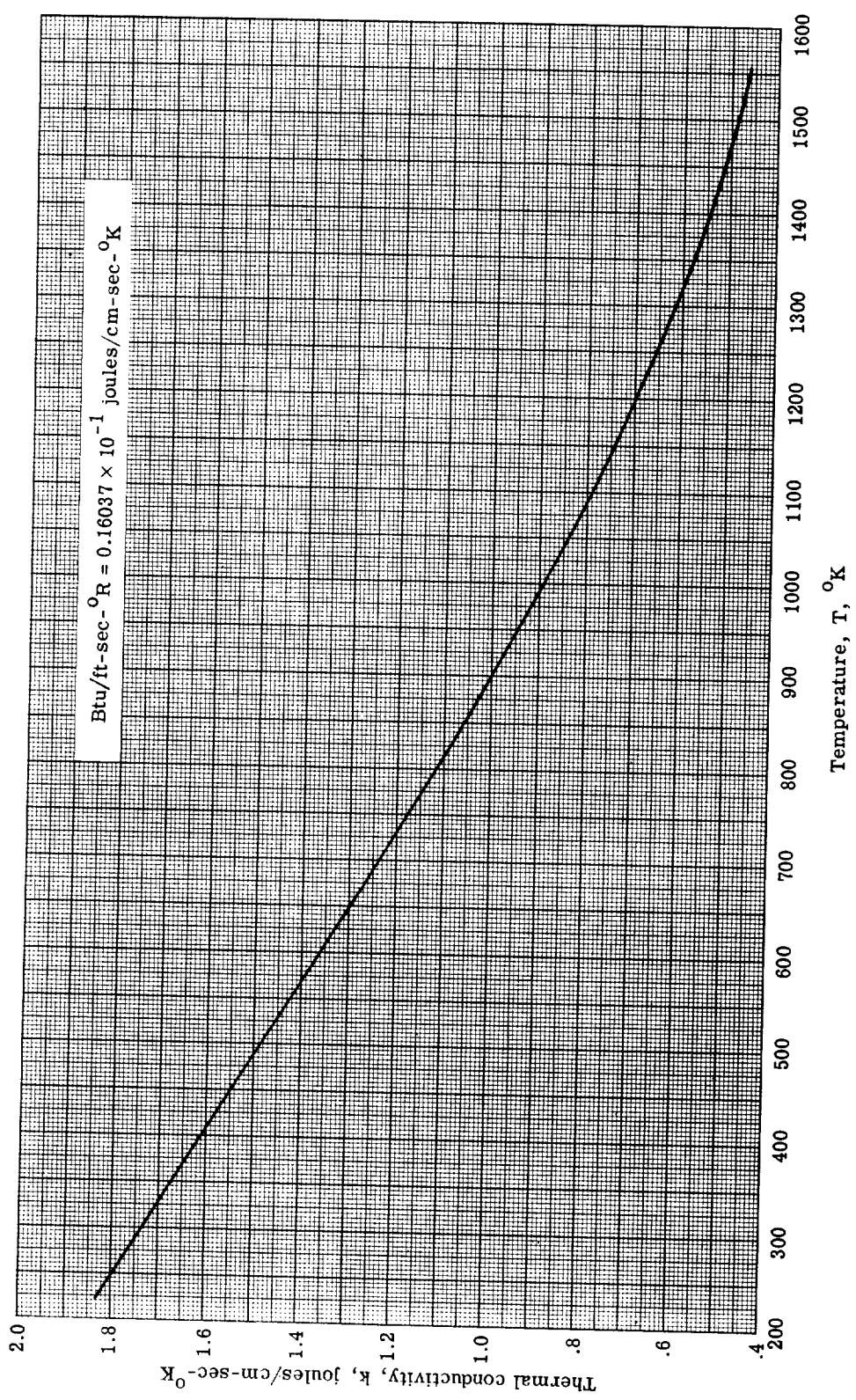


Figure 9.- Variation of thermal conductivity of beryllium with temperature.

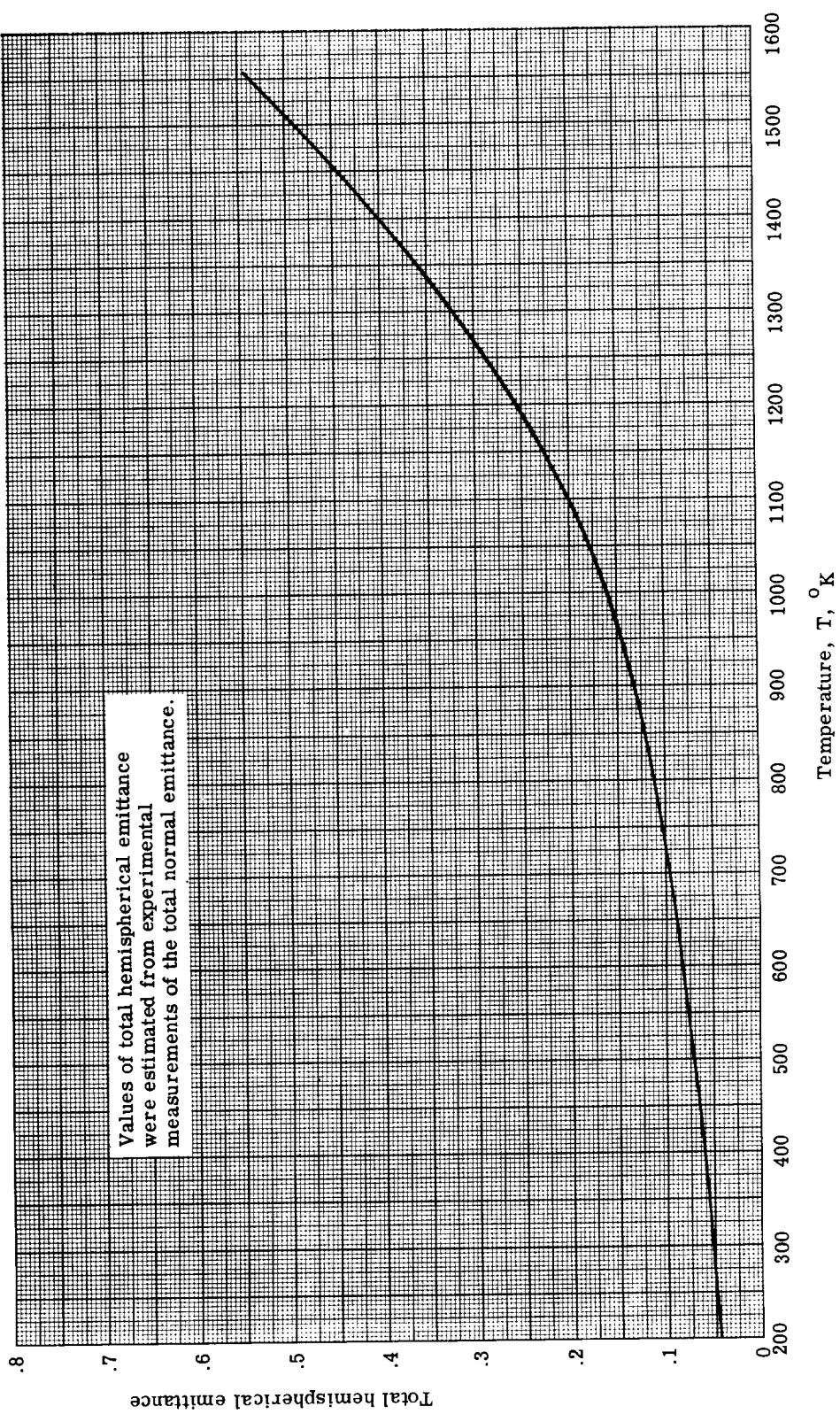


Figure 10.- Variation of total hemispherical emittance of beryllium with temperature.

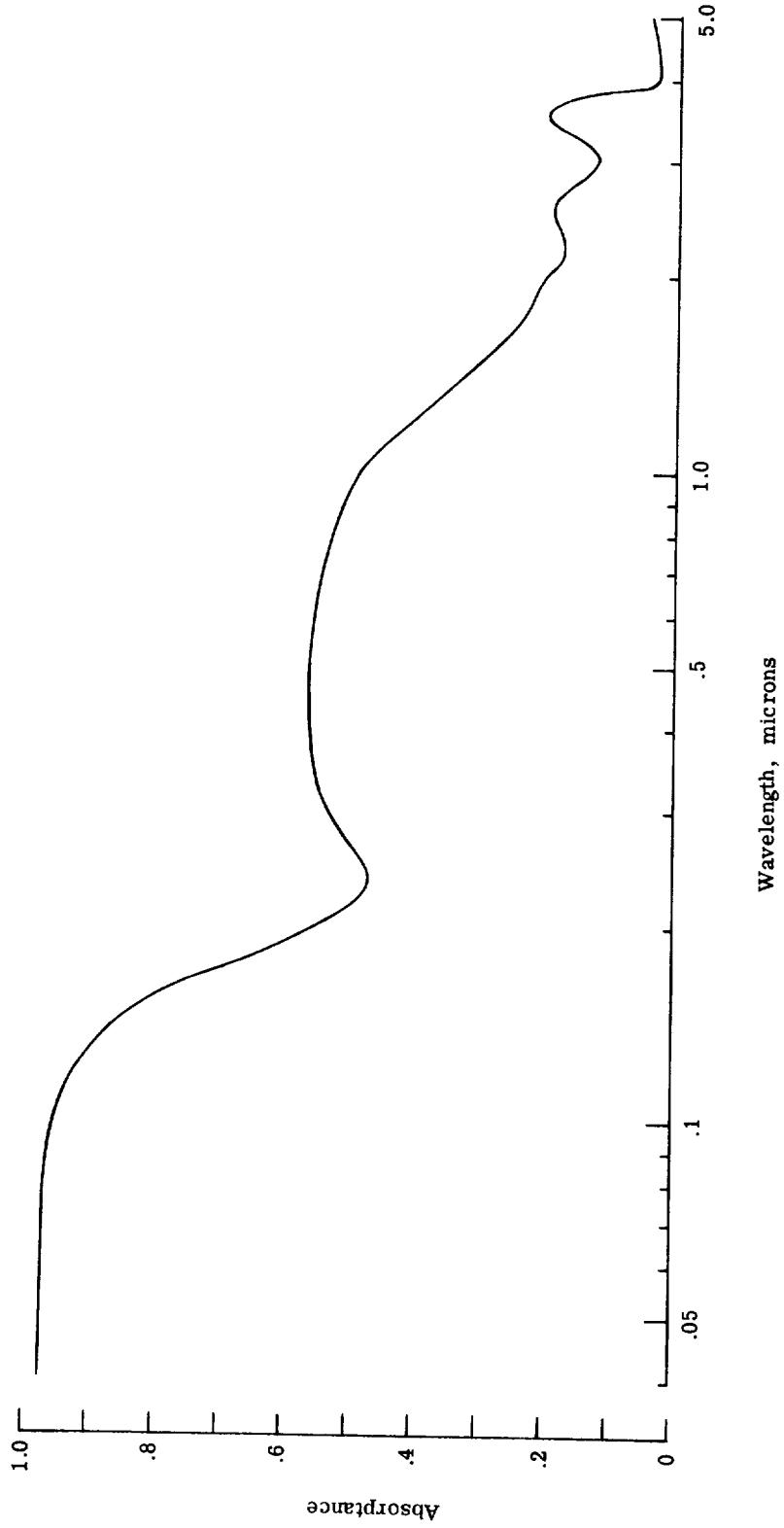


Figure 11.- Spectral absorptance characteristics of polished beryllium at room temperature.

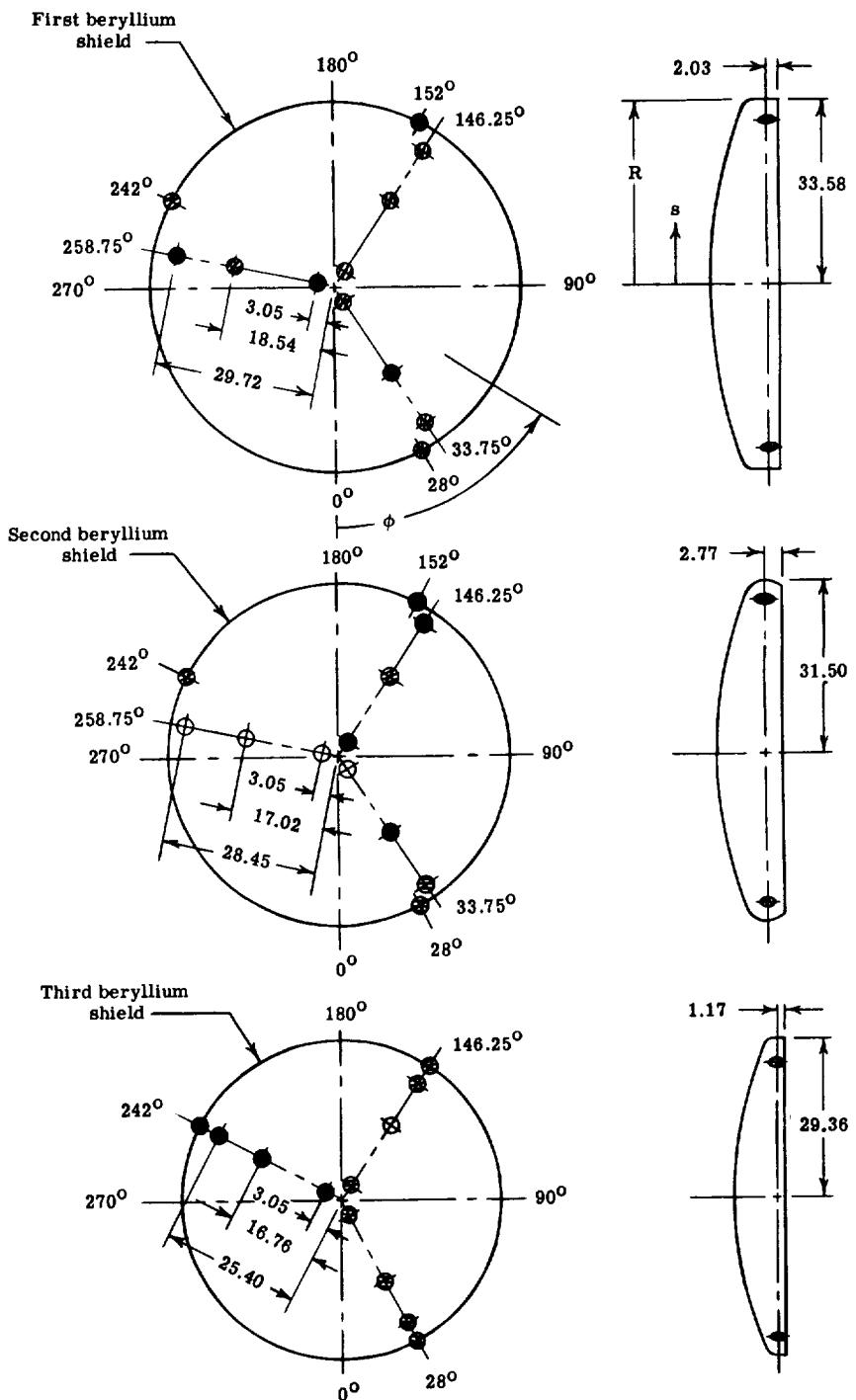
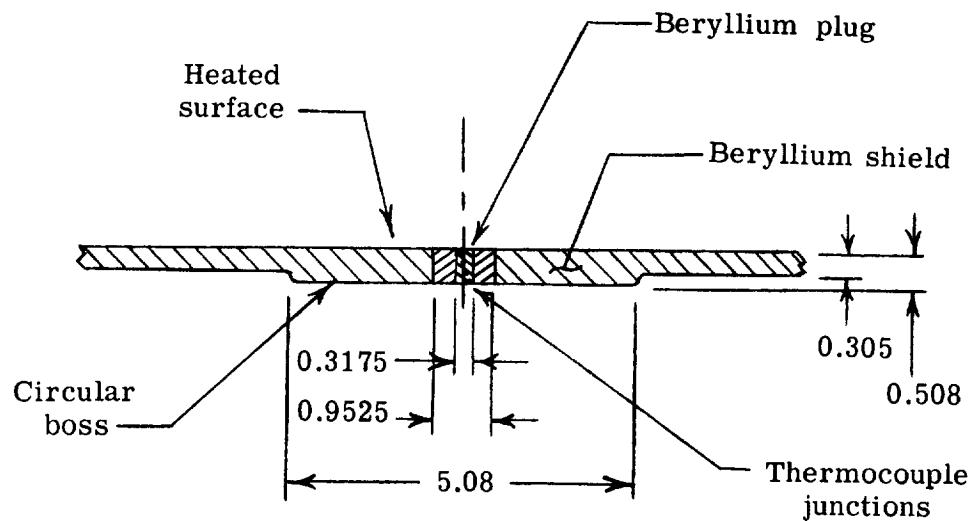
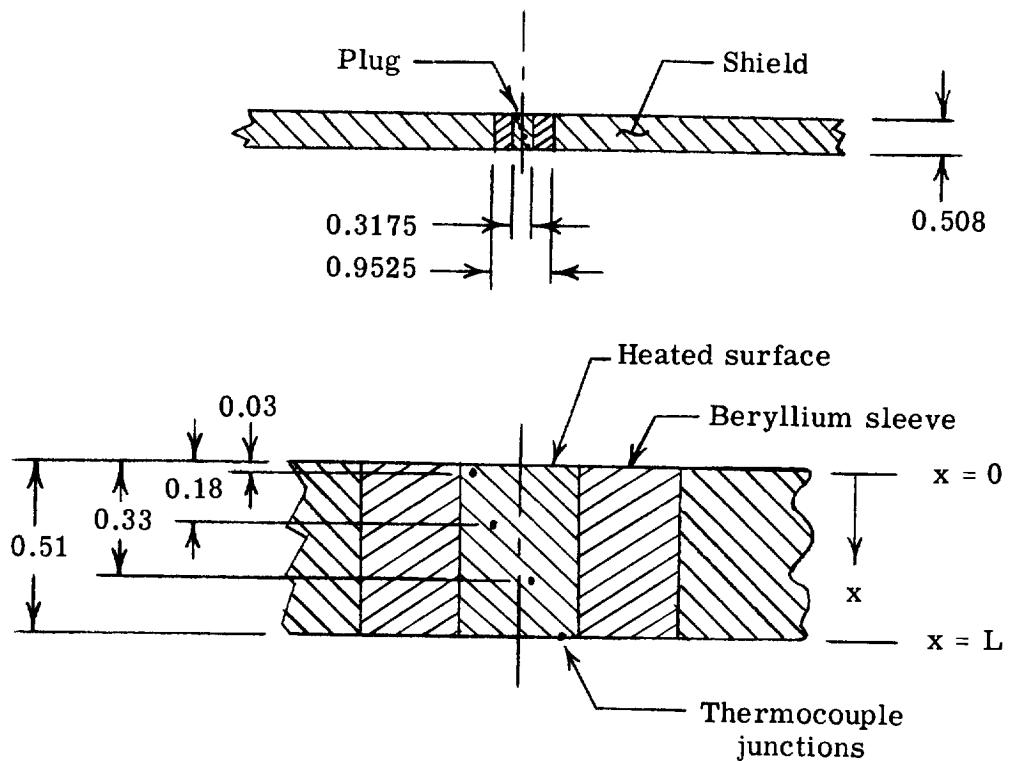


Figure 12.- Location of plugs in three beryllium calorimeter layers on forebody of Project Fire reentry package. All linear dimensions are in centimeters. Plugs shown blackened are those for which heating rates are presented. Radial dimensions shown are the same for plugs in other rays.



(a) Typical plug installation illustrating bosses used on first and third beryllium shields.



(b) Typical plug installation for second beryllium shield and nominal thermocouple depths.

Figure 13.- Sketch of beryllium plug installations. All dimensions are shown in centimeters.

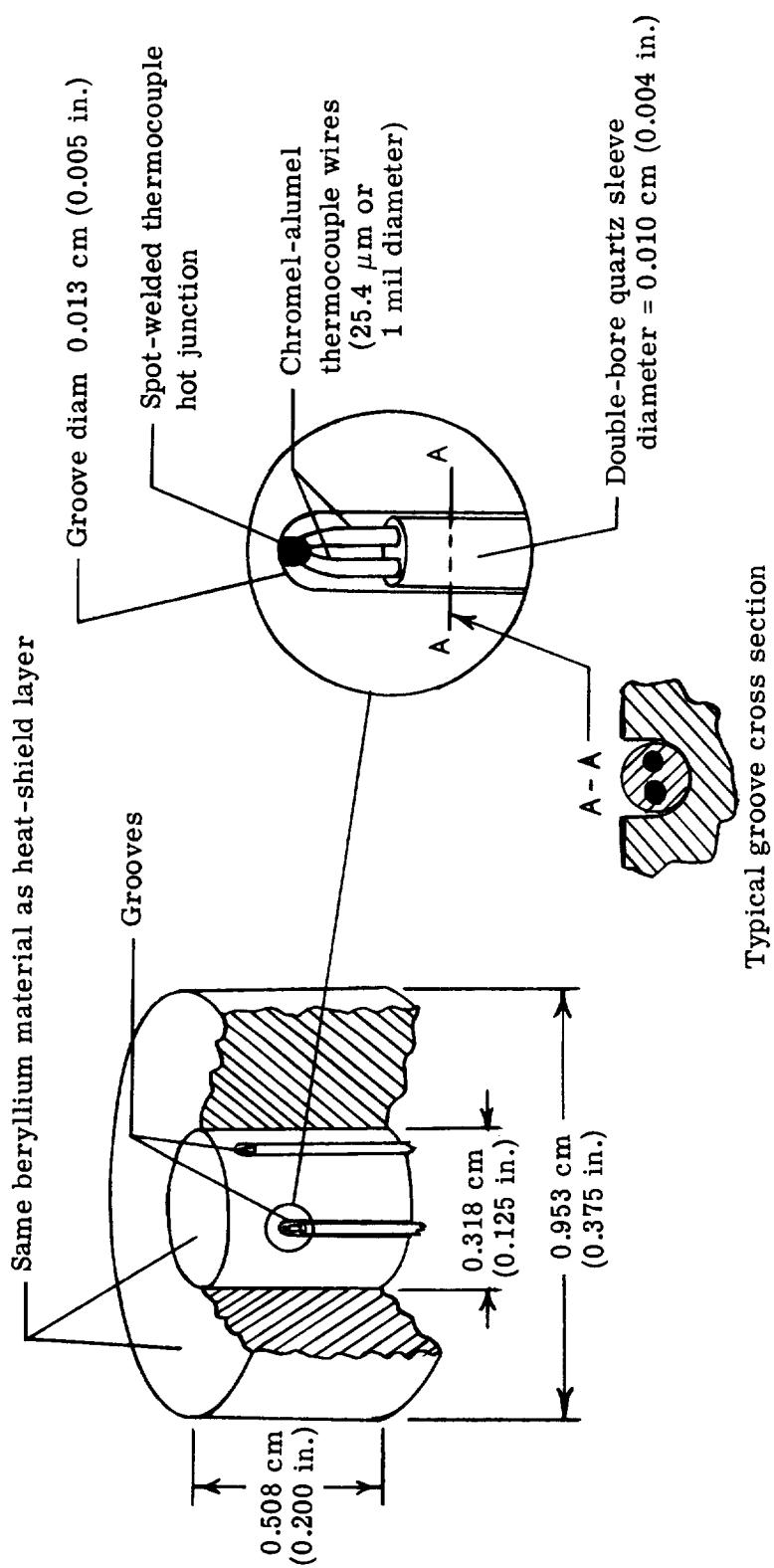
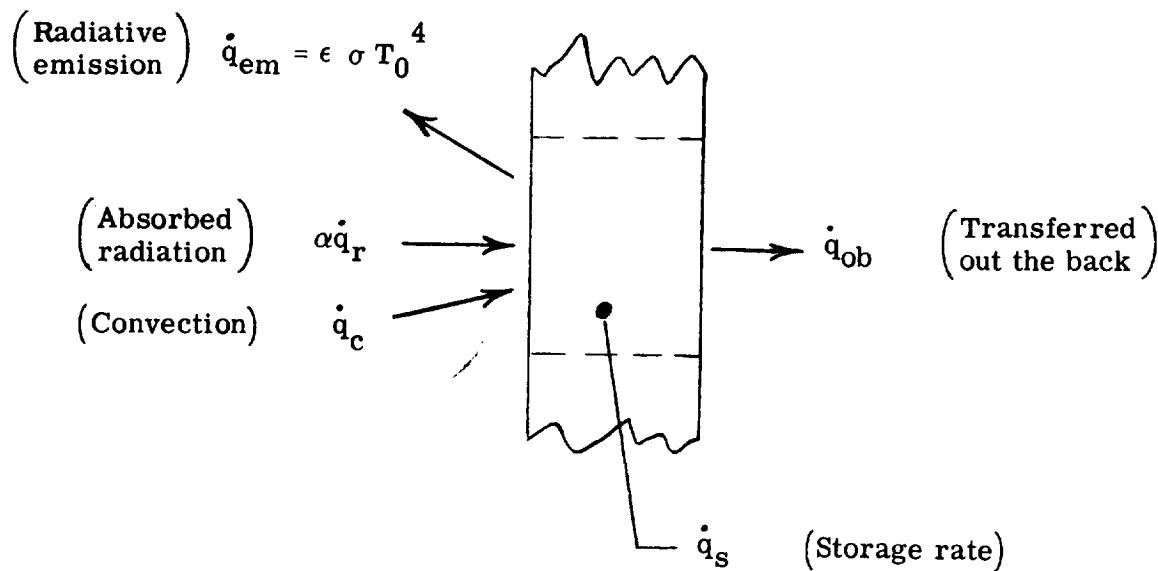


Figure 14.- Typical thermocouple installation and forebody calorimeter plug.

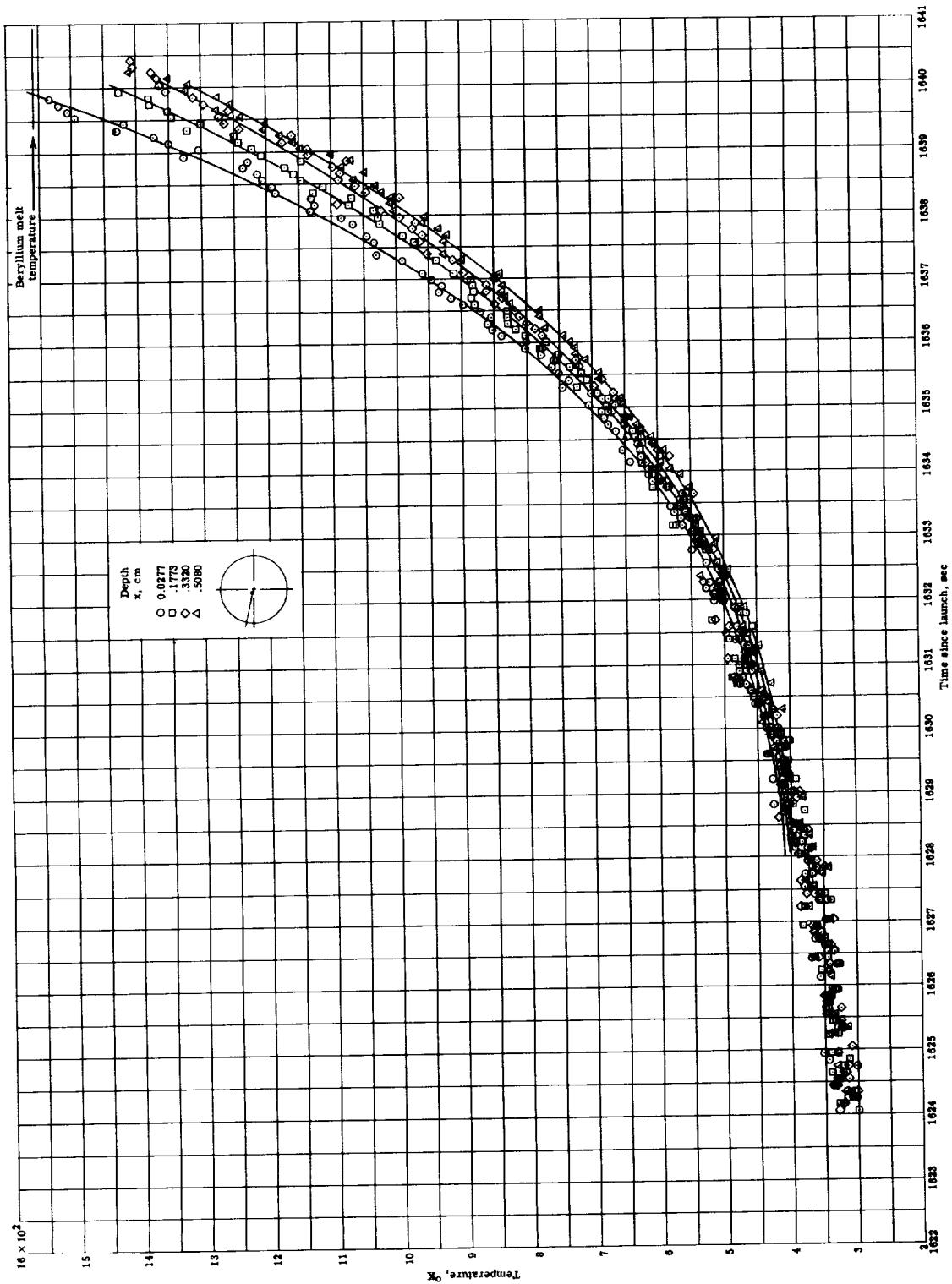


$$\text{HEAT IN} = \text{HEAT STORED} + \text{HEAT OUT}$$

$$\dot{q}_c + \alpha \dot{q}_r = \dot{q}_s + \epsilon \sigma T_0^4 + \dot{q}_{ob}$$

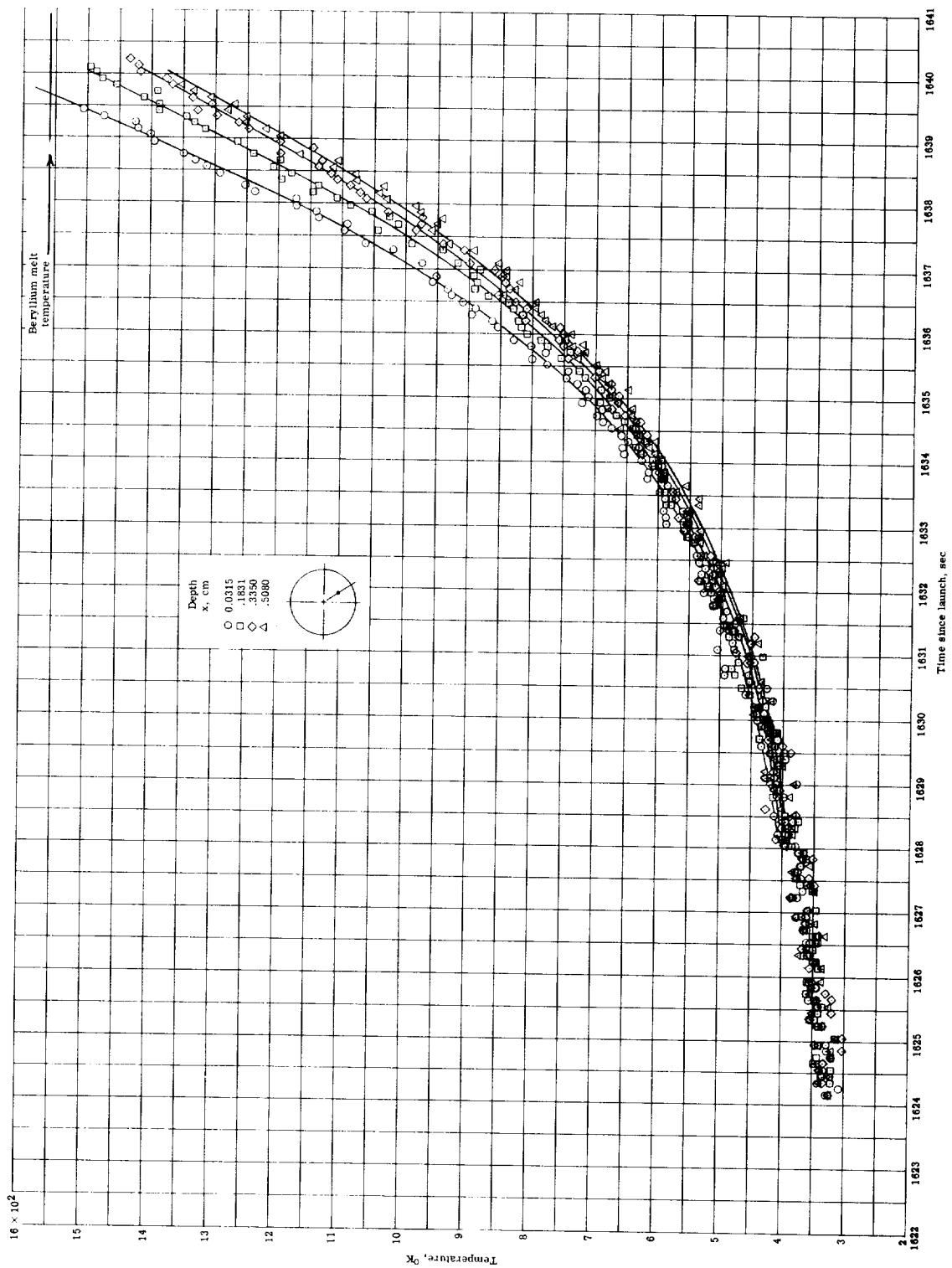
Calculated from Fire data
 Experimentally measured
 Known constant
 Calculated from Fire data

Figure 15.- Theoretical model and basic heat balance for a typical forebody beryllium calorimeter plug.



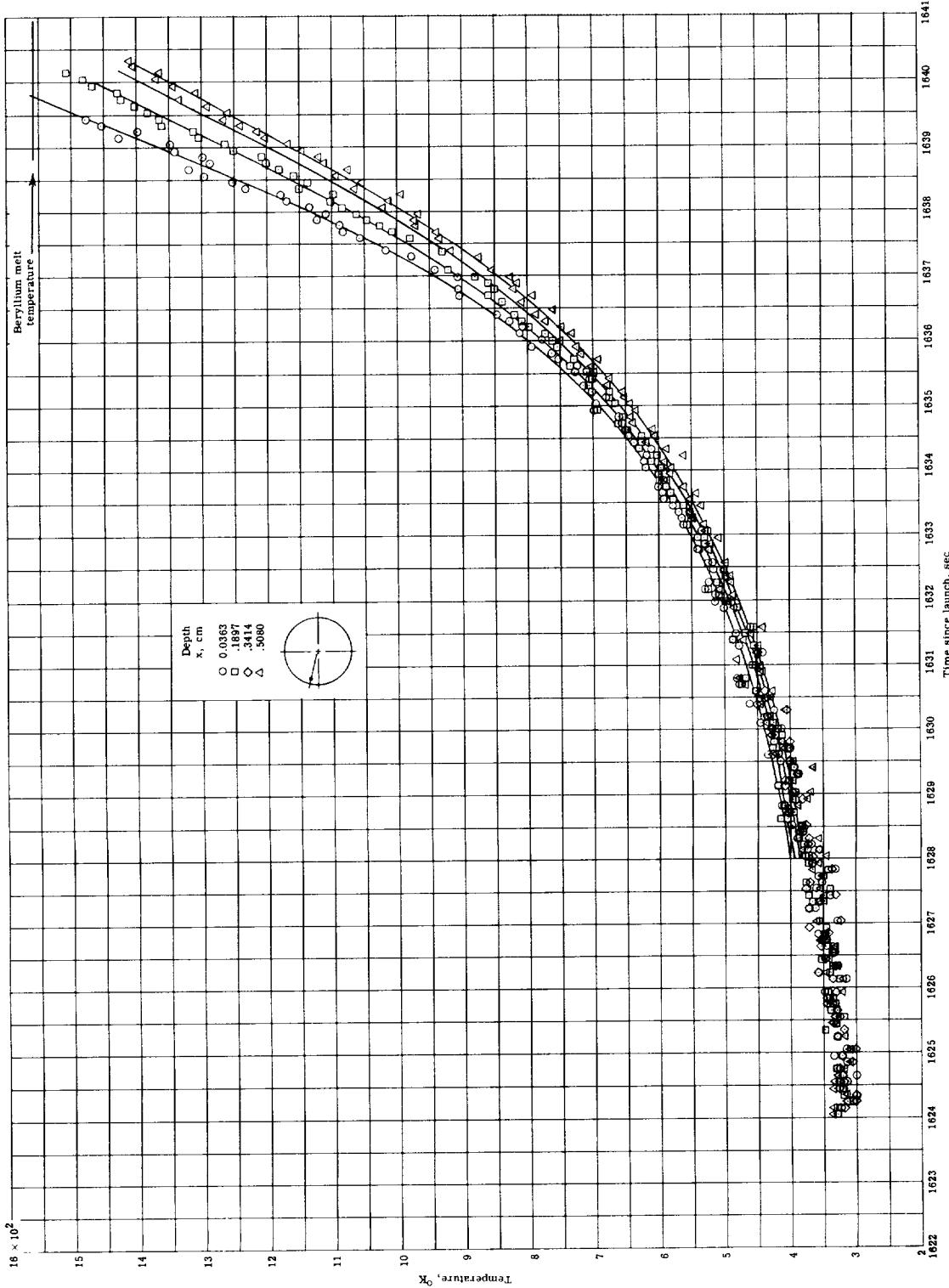
(a) $s/R = 0.09$; $\Phi = 258.75^\circ$.

Figure 16.- Temperature-time histories measured in first forebody beryllium calorimeter layer (solid lines are curve fits of the data).



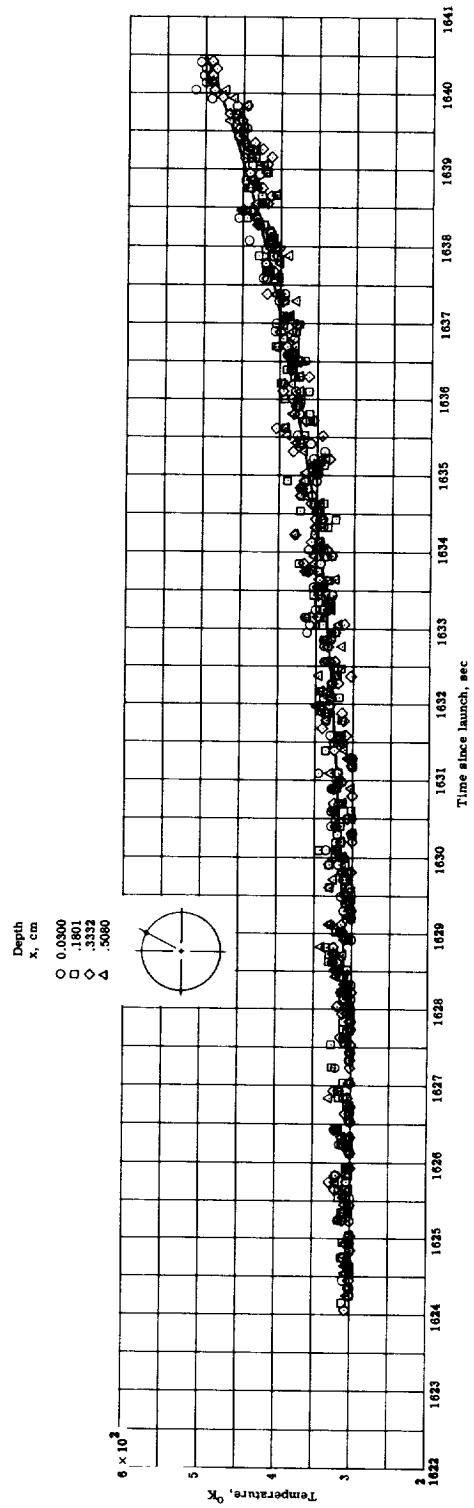
(b) $s/R = 0.55; \Phi = 33.75^\circ$.

Figure 16.- Continued.



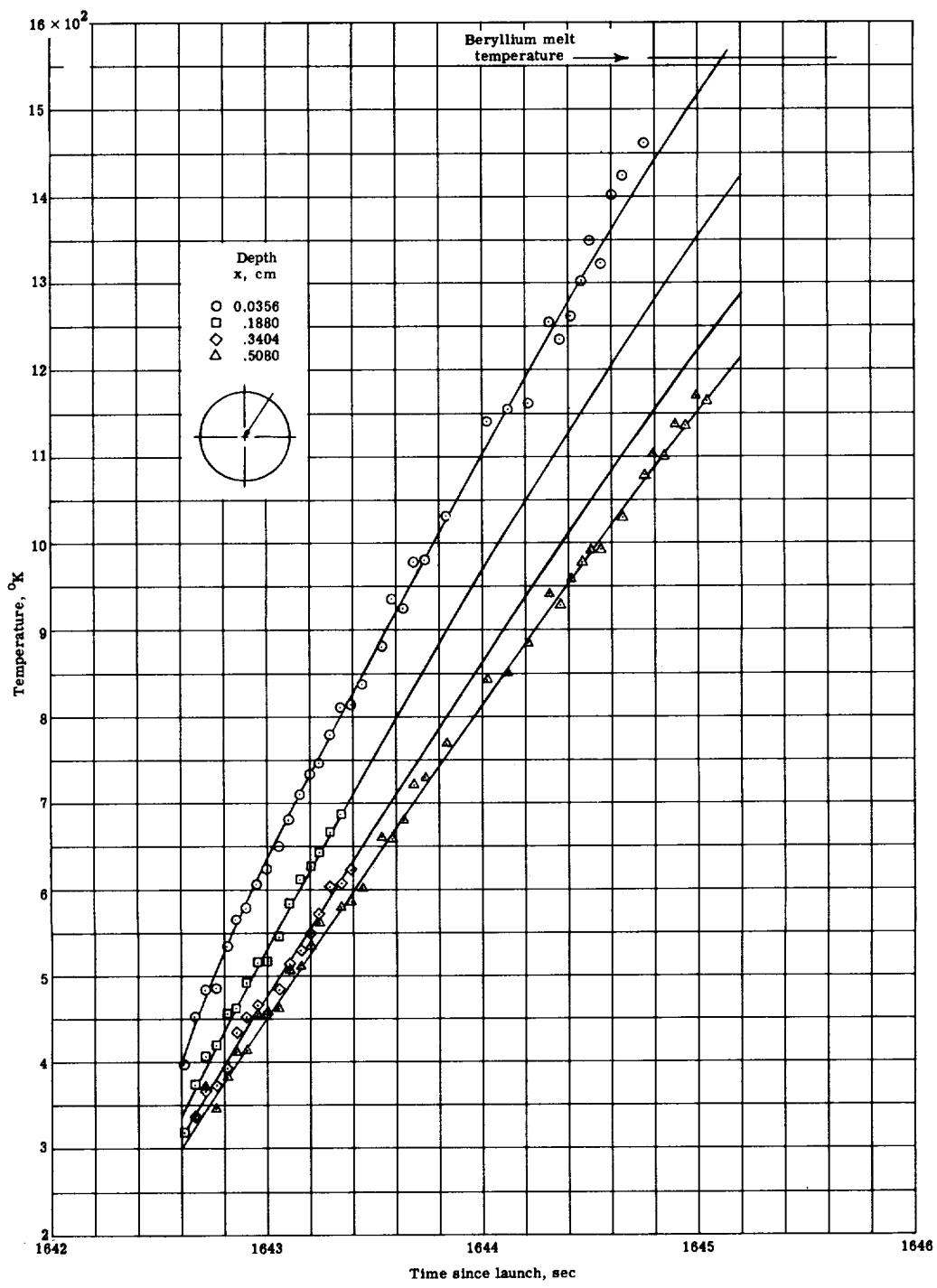
(c) $s/R = 0.89$; $\Phi = 258.75^\circ$.

Figure 16.- Continued.



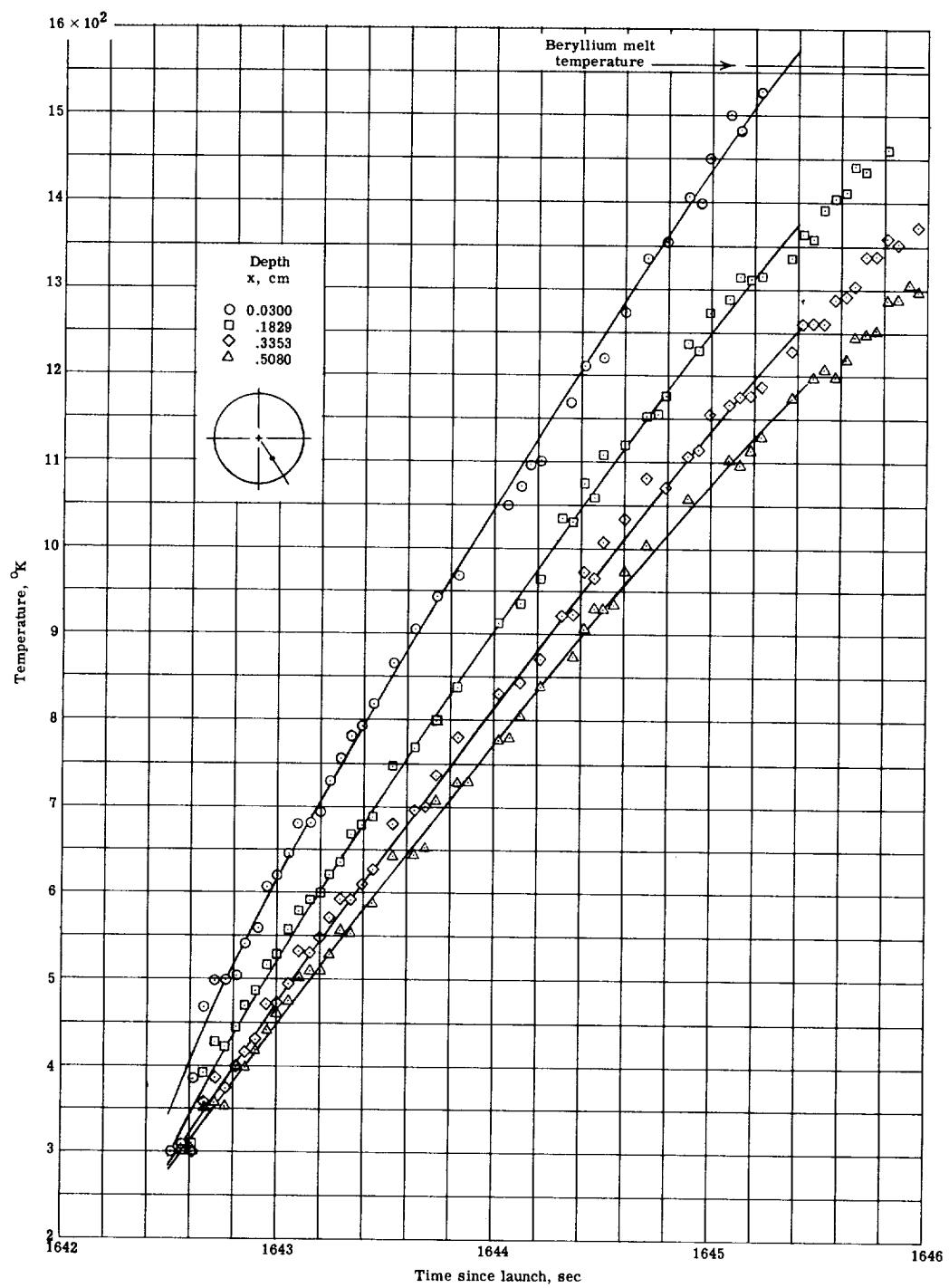
(d) $s/R = 1.00$; $\phi = 152.00^\circ$.

Figure 16.- Concluded.



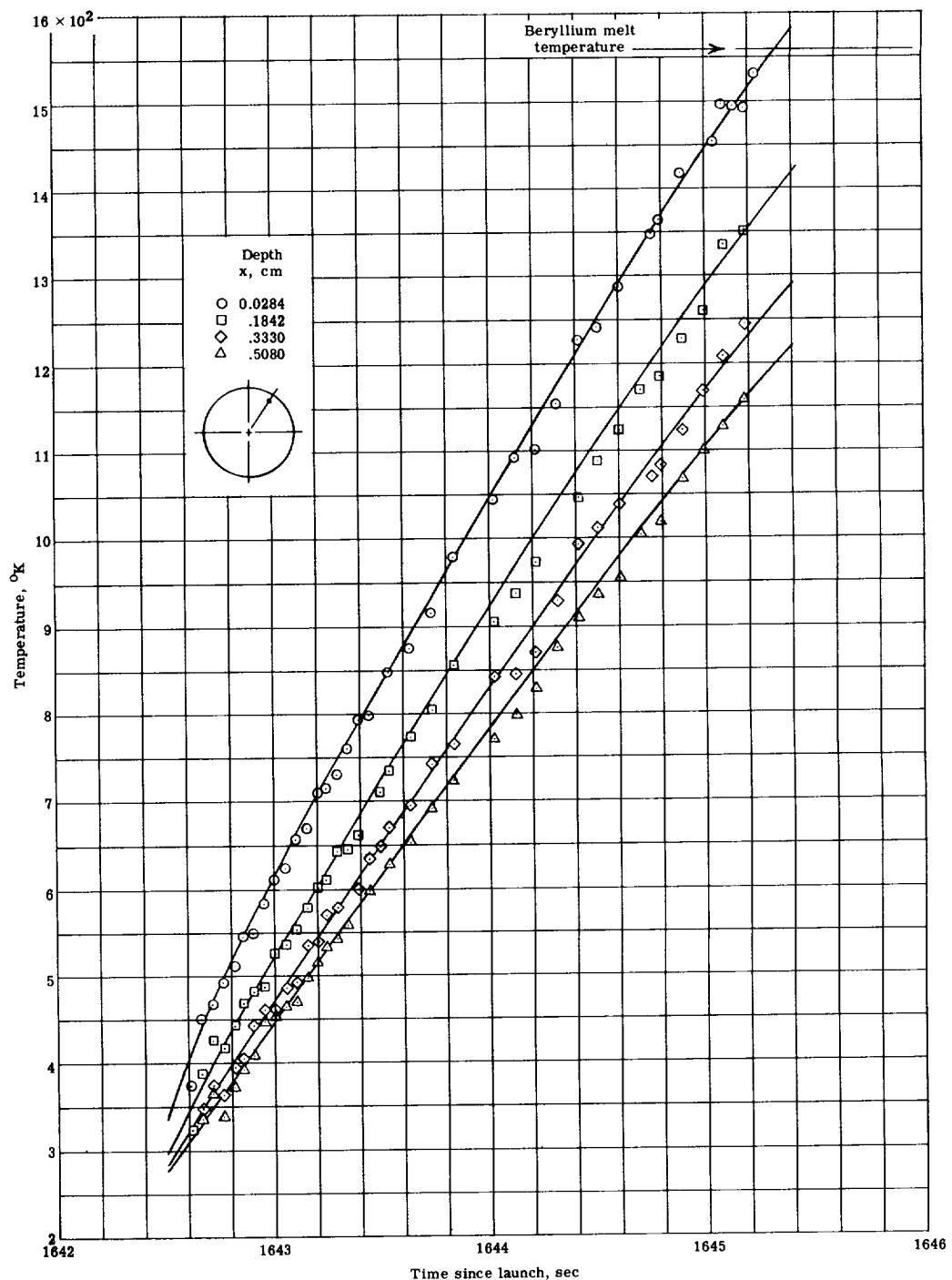
(a) $s/R = 0.10; \Phi = 146.25^{\circ}$.

Figure 17.- Temperature-time histories measured in second forebody beryllium calorimeter layer (solid lines are curve fits of the data).



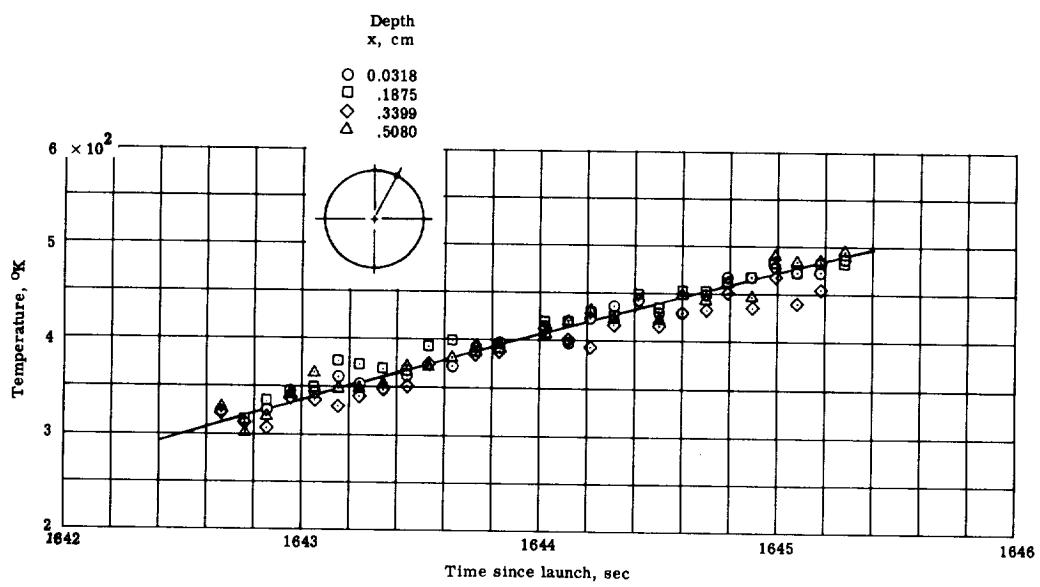
(b) $s/R = 0.54$; $\Phi = 33.75^\circ$.

Figure 17.- Continued.



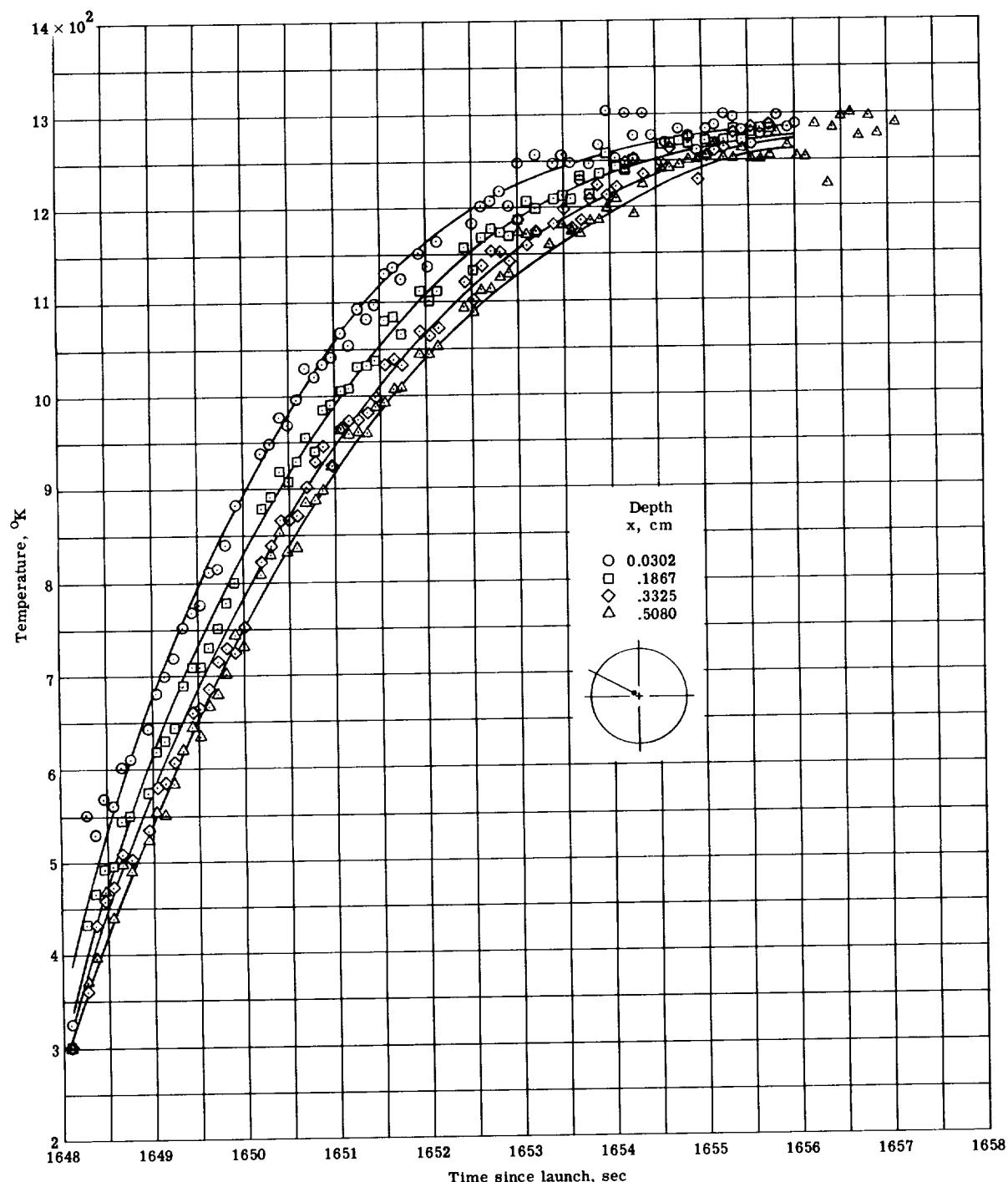
(c) $s/R = 0.90; \Phi = 146.25^\circ$.

Figure 17.- Continued.



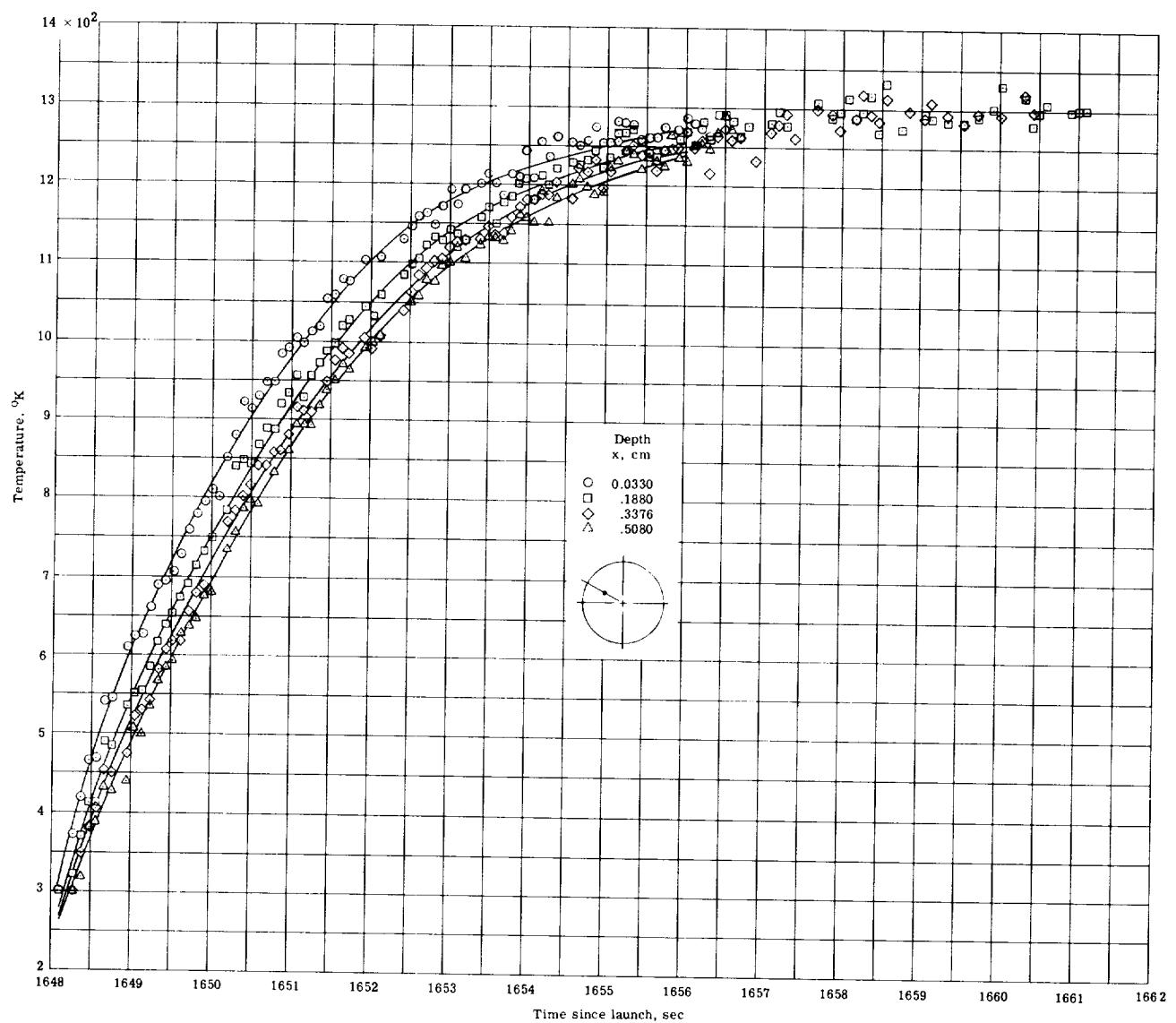
(d) $s/R = 1.00$; $\Phi = 152.00^{\circ}$.

Figure 17.- Concluded.



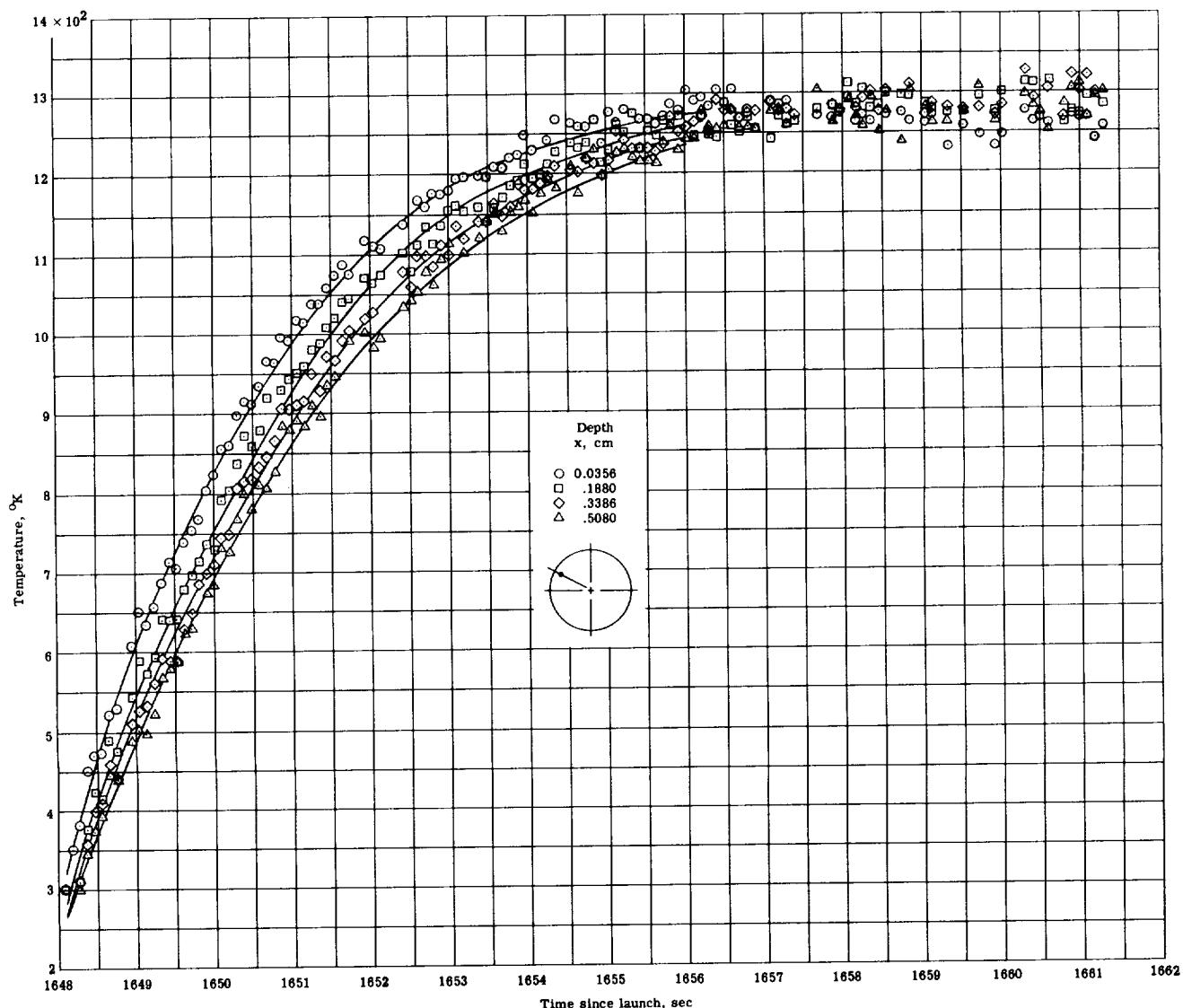
(a) $s/R = 0.10; \Phi = 242.00^\circ$.

Figure 18.- Temperature-time histories measured in third forebody beryllium calorimeter layer (solid lines are curve fits of the data).



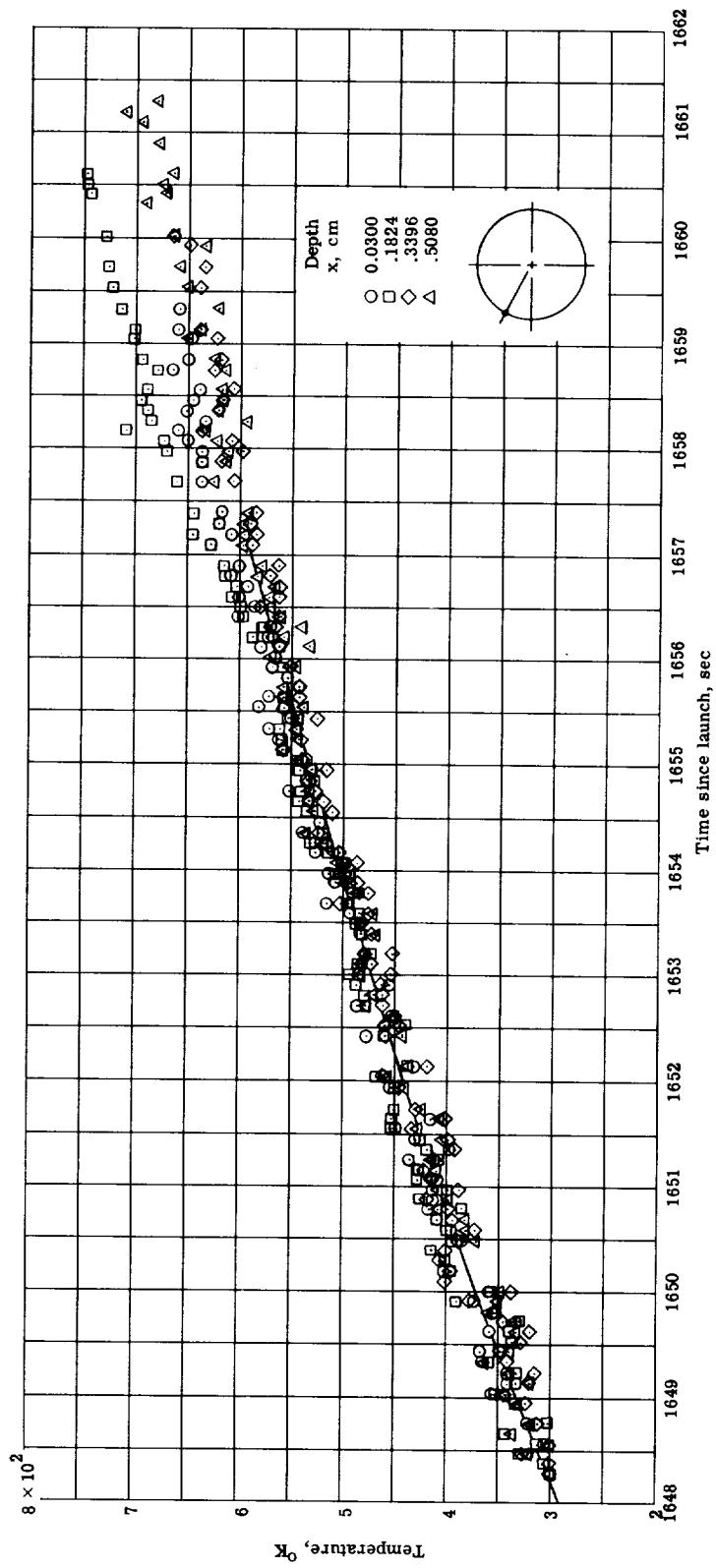
(b) $s/R = 0.57$; $\Phi = 242.00^{\circ}$.

Figure 18.- Continued.



(c) $s/R = 0.87; \Phi = 242.00^\circ$.

Figure 18.- Continued.



(d) $s/R = 1.00$; $\Phi = 242.00^{\circ}$.

Figure 18. - Concluded.

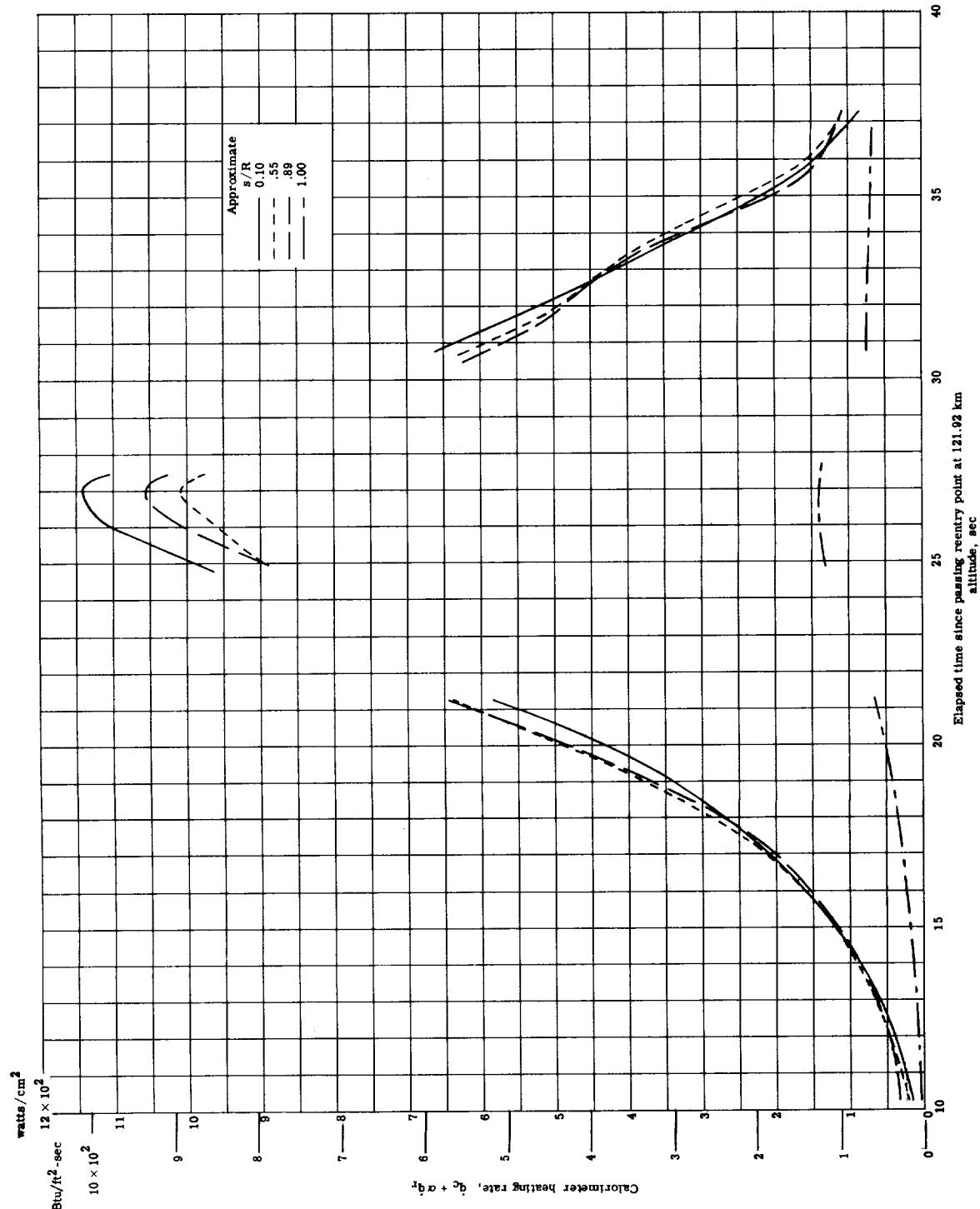
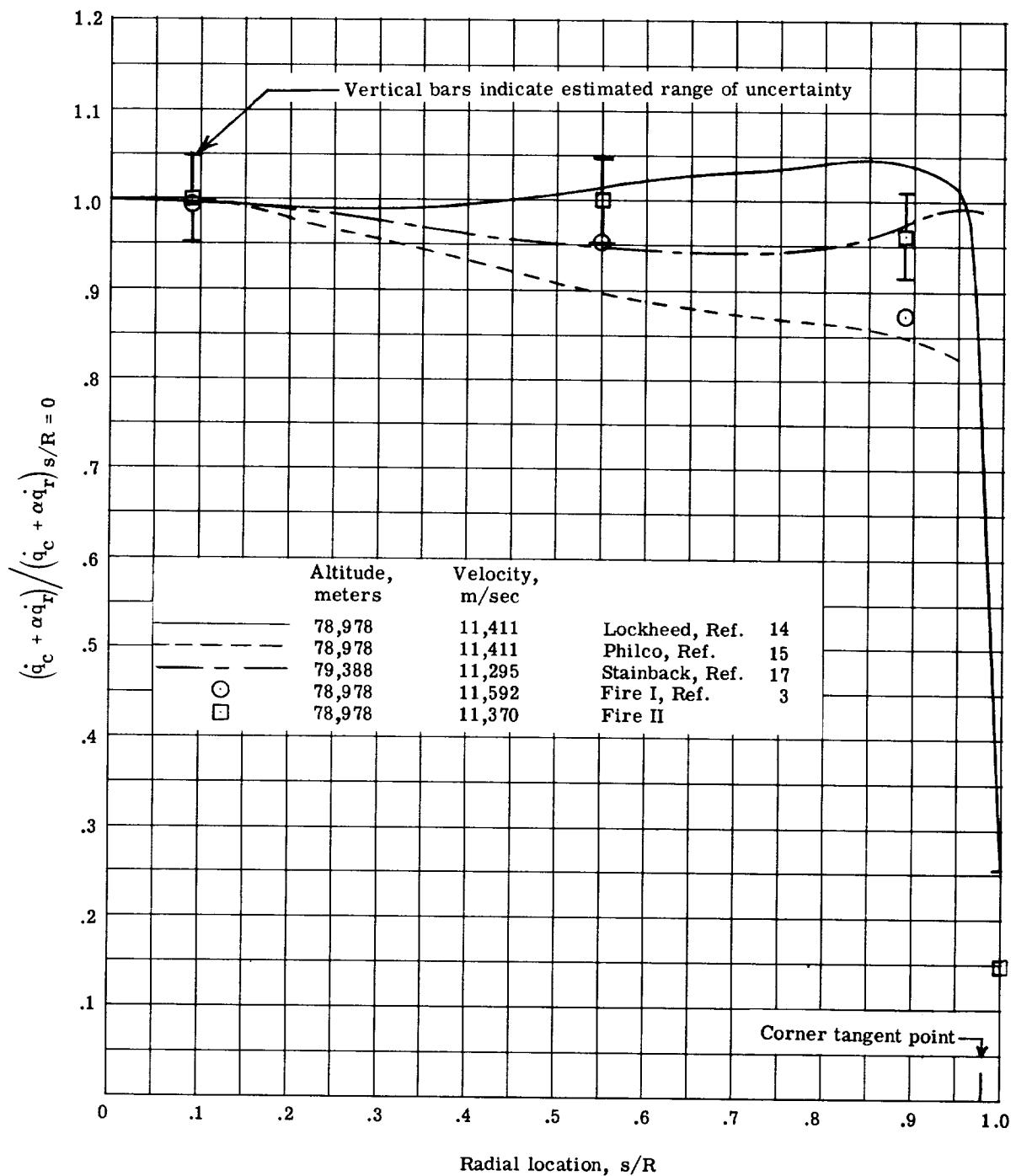
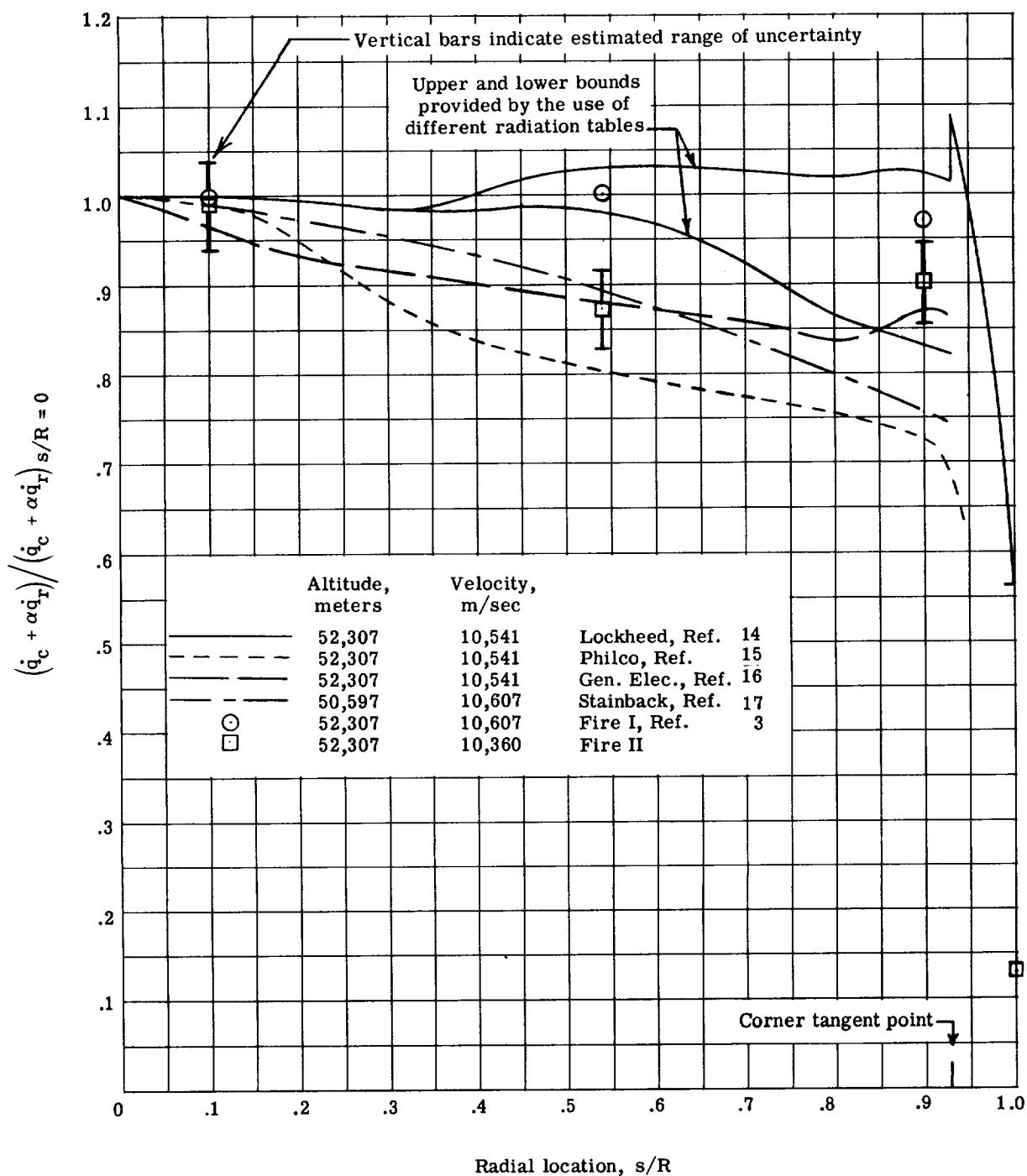


Figure 19.- Comparison of calorimeter heating rates at four radial locations on forebody of reentry package.



(a) First experimental period.

Figure 20.- Comparison of experimental and predicted radial distribution of heat flux over forebody (vertical lines indicate limits of accuracy for calorimeter heat flux).



(b) Second experimental period.

Figure 20.- Concluded.

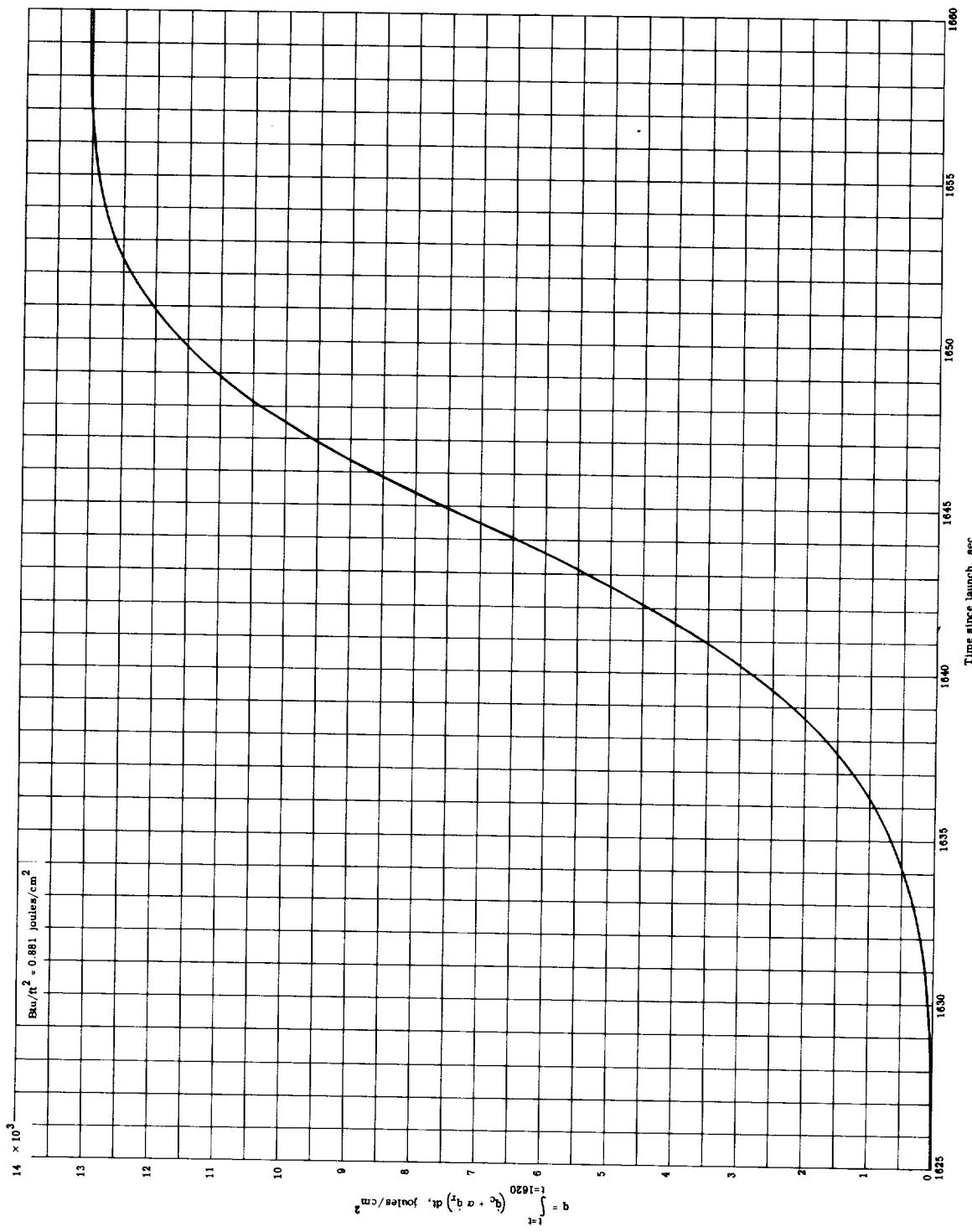


Figure 21. Accumulative heat load experienced by forebody of Fire II reentry package.

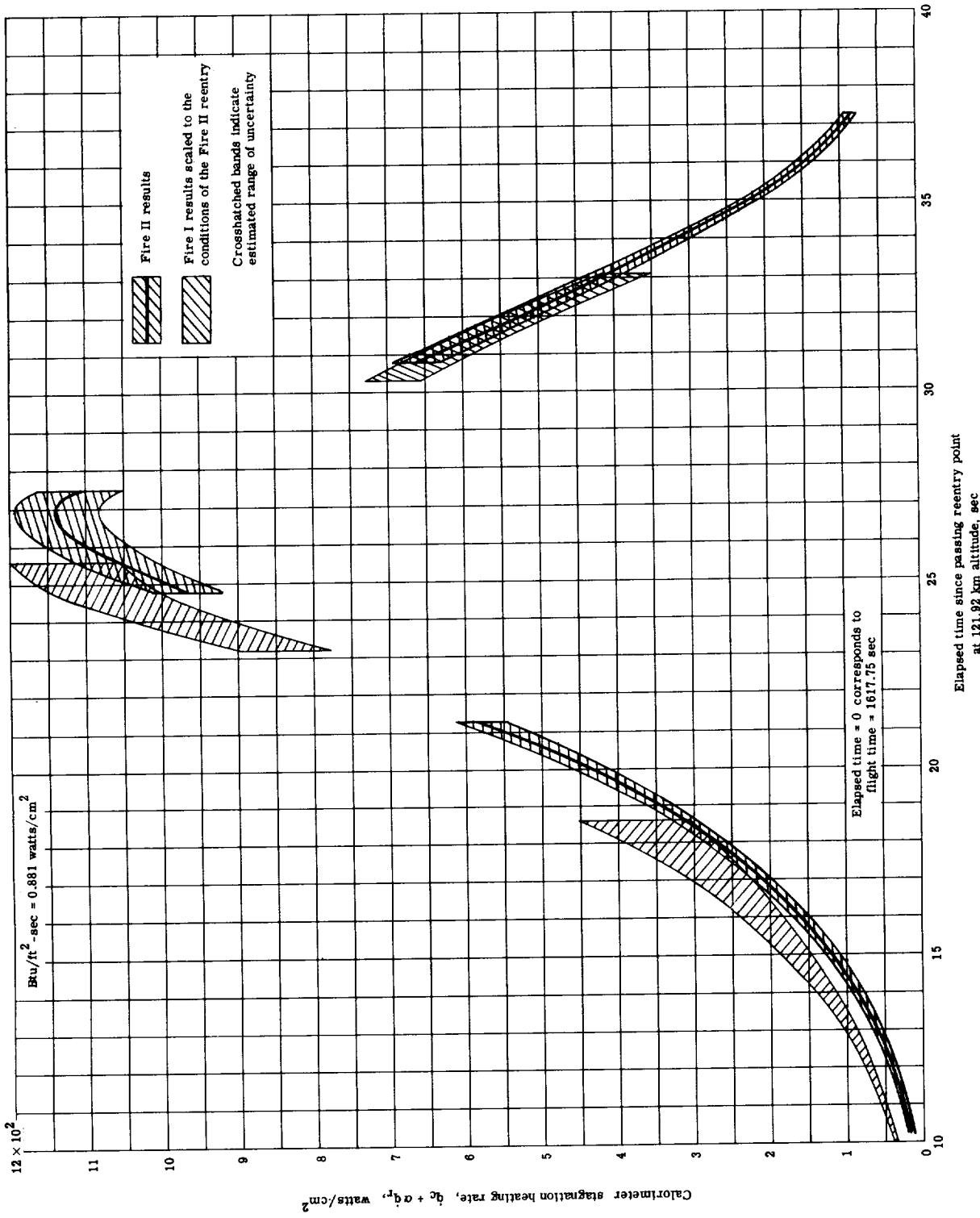


Figure 22.- Comparison of calorimeter stagnation heating rates for Fire I and Fire II reentries.

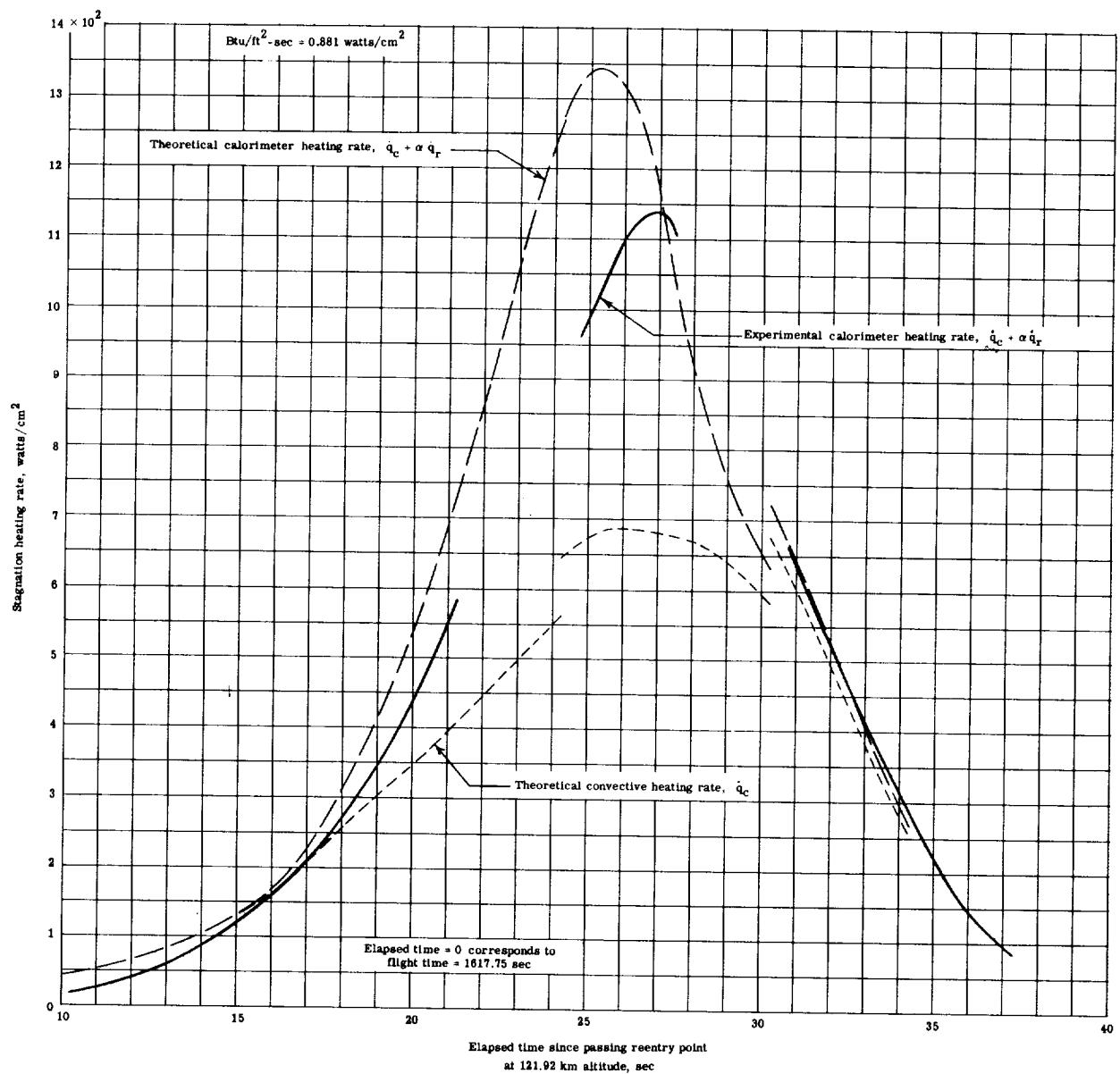


Figure 23.- Comparison of measured and predicted heating rates for Fire II reentry ($s/R = 0.09$).